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He et al.

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(54) **HYBRID AUTOMATIC REPEAT REQUEST (HARQ) MAPPING FOR CARRIER AGGREGATION (CA)**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 260 days.

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Related U.S. Application Data

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(51) **Int. Cl.**
H04L 1/18 (2006.01)
H04L 5/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04W 24/10*** (2013.01); ***H04B 5/00*** (2013.01); ***H04B 17/318*** (2015.01); ***H04J 3/1694*** (2013.01); ***H04J 11/0086*** (2013.01); ***H04L 1/1812*** (2013.01); ***H04L 1/1864*** (2013.01); ***H04L 5/0035*** (2013.01); ***H04L 5/0055*** (2013.01); ***H04L 5/0057*** (2013.01); ***H04L 5/0073*** (2013.01); ***H04L 5/14*** (2013.01); ***H04L 41/5032*** (2013.01); ***H04L 65/60*** (2013.01); ***H04L 65/602*** (2013.01); ***H04L 67/10*** (2013.01); ***H04W 4/005*** (2013.01); ***H04W 8/08*** (2013.01); ***H04W 24/08*** (2013.01); ***H04W 28/0215*** (2013.01); ***H04W 28/0221*** (2013.01); ***H04W 28/08*** (2013.01); ***H04W 28/16*** (2013.01); ***H04W 36/0061*** (2013.01); ***H04W 36/0083*** (2013.01);
(Continued)

(58) **Field of Classification Search**
None
See application file for complete search history.

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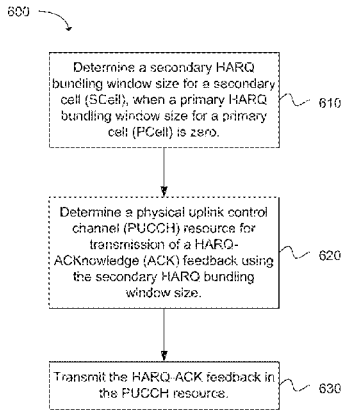
(57) **ABSTRACT**

Technology to dynamically alter hybrid automatic retransmission re-quest (HARQ) mapping for carrier aggregation (CA) is disclosed. In an example, a user equipment (UE) operable to dynamically alter hybrid automatic retransmission re-quest (HARQ) mapping for carrier aggregation (CA) can include computer circuitry configured to: Determine a secondary HARQ bundling window size for a secondary cell (SCell), when a primary HARQ bundling window size for a primary cell (PCell) is zero; determine a physical uplink control channel (PUCCH) resource for transmission of a HARQ-ACKnowledge (ACK) feedback using the secondary HARQ bundling window size; and transmit the HARQ-ACK feedback in the PUCCH resource.

18 Claims, 21 Drawing Sheets



(51) **Int. Cl.**

H04W 72/04	(2009.01)
H04W 24/10	(2009.01)
H04W 72/12	(2009.01)
H04W 74/00	(2009.01)
H04W 48/14	(2009.01)
H04W 72/02	(2009.01)
H04W 76/02	(2009.01)
H04W 88/02	(2009.01)
H04B 17/318	(2015.01)
H04W 36/00	(2009.01)
H04W 76/04	(2009.01)
H04W 4/00	(2009.01)
H04W 24/08	(2009.01)
H04W 28/02	(2009.01)
H04W 40/24	(2009.01)
H04W 48/16	(2009.01)
H04W 52/02	(2009.01)
H04W 52/04	(2009.01)
H04W 52/14	(2009.01)
H04B 5/00	(2006.01)
H04J 3/16	(2006.01)
H04L 5/14	(2006.01)
H04L 29/06	(2006.01)
H04L 29/08	(2006.01)
H04W 8/08	(2009.01)
H04W 28/08	(2009.01)
H04W 36/22	(2009.01)
H04W 48/20	(2009.01)
H04L 12/24	(2006.01)
H04W 28/16	(2009.01)
H04J 11/00	(2006.01)
H04W 72/00	(2009.01)
H04W 80/10	(2009.01)
H04W 36/08	(2009.01)
H04W 48/18	(2009.01)
H04W 88/18	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 36/0088*** (2013.01); ***H04W 36/22*** (2013.01); ***H04W 40/246*** (2013.01); ***H04W 48/14*** (2013.01); ***H04W 48/16*** (2013.01); ***H04W 48/20*** (2013.01); ***H04W 52/0209*** (2013.01); ***H04W 52/0212*** (2013.01); ***H04W 52/0235*** (2013.01); ***H04W 52/04*** (2013.01); ***H04W 52/14*** (2013.01); ***H04W 72/02*** (2013.01); ***H04W 72/042*** (2013.01); ***H04W 72/044*** (2013.01); ***H04W 72/0406*** (2013.01); ***H04W 72/0413*** (2013.01); ***H04W 72/0486*** (2013.01); ***H04W 72/1284*** (2013.01); ***H04W 74/002*** (2013.01); ***H04W 74/004*** (2013.01); ***H04W 76/022*** (2013.01); ***H04W 76/025*** (2013.01); ***H04W 76/043*** (2013.01); ***H04W 76/046*** (2013.01); ***H04W 76/048*** (2013.01); ***H04W 88/02*** (2013.01); *H04L 5/001* (2013.01); *H04W 36/08* (2013.01); *H04W 48/18* (2013.01); *H04W 52/0261* (2013.01); *H04W 72/005* (2013.01); *H04W 80/10* (2013.01); *H04W 88/18* (2013.01); *Y02B 60/50* (2013.01)

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3GPP TSG RAN1, "Remaining Details on HARQ-ACK Transmission for TDD CA with Different TDD UL-DL Configuration", R1-123322, # 70, Aug. 13-17, 2012, 8 pages.

3GPP TSG RAN WG1, "PUCCH 1b with Channel Selection for HARQ-ACK Transmission in TDD Inter Band CA", Rl-123663, Meeting # 70, Aug. 13-17, 2012, 4 pages.

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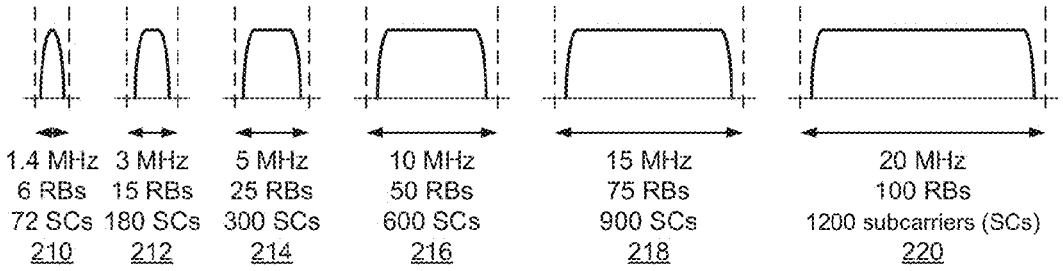

1.4 MHz
6 RBs
72 SCs
210
3 MHz
15 RBs
180 SCs
212
5 MHz
25 RBs
300 SCs
214
10 MHz
50 RBs
600 SCs
216
15 MHz
75 RBs
900 SCs
218
20 MHz
100 RBs
1200 subcarriers (SCs)
220

FIG. 1

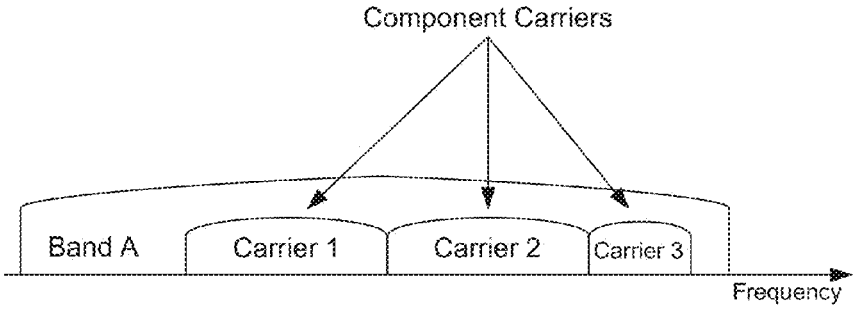


FIG. 2A

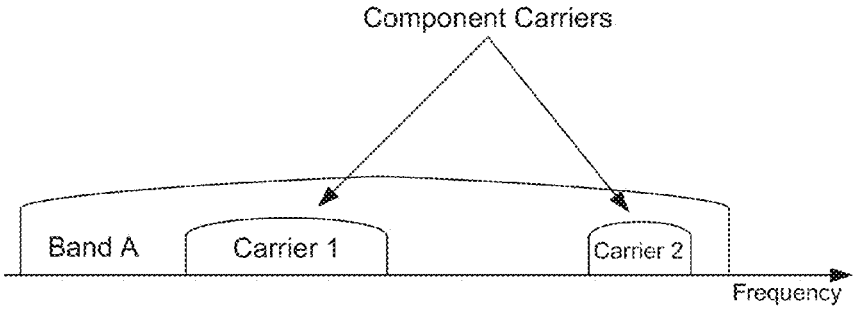


FIG. 2B

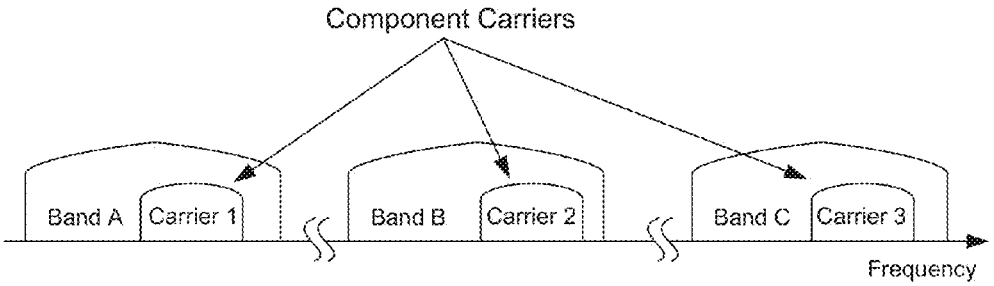


FIG. 2C

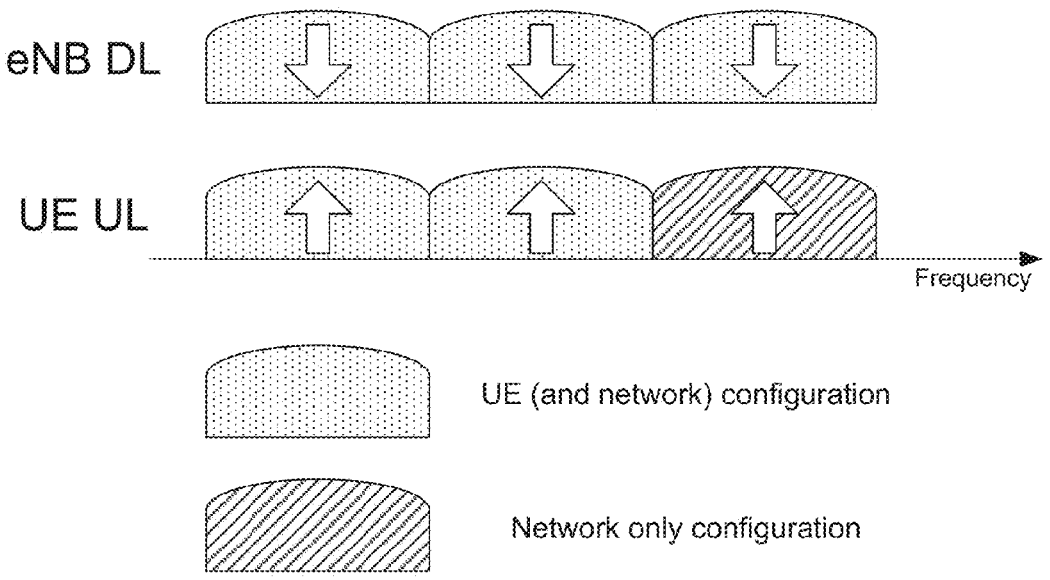

eNB DL
UE UL
Frequency
UE (and network) configuration
Network only configuration

FIG. 3A

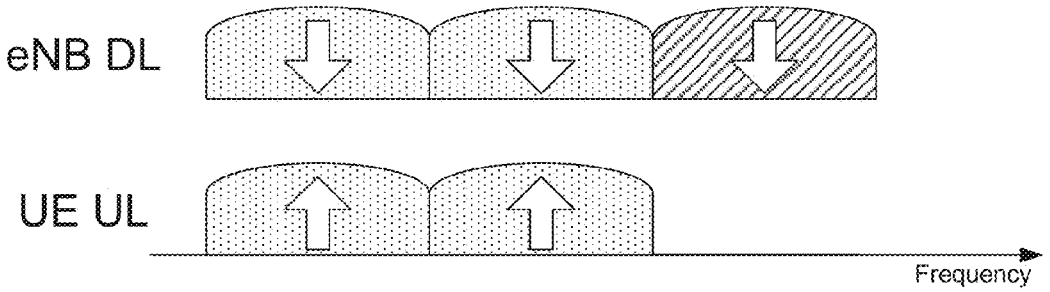

eNB DL
UE UL
Frequency

FIG. 3B

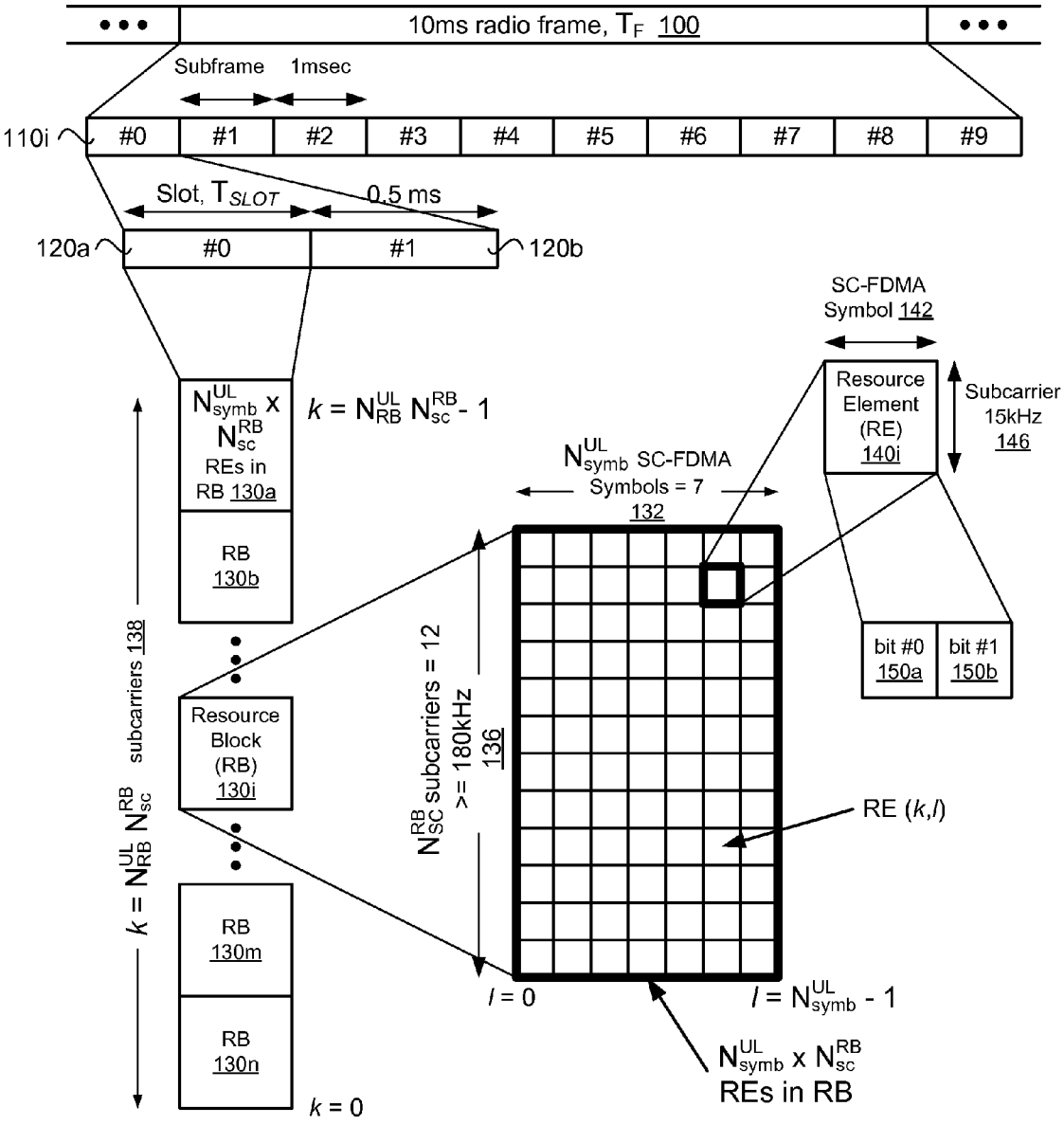

10ms radio frame, T_F 100
Subframe 1msec
110i
#0 #1 #2 #3 #4 #5 #6 #7 #8 #9
Slot, T_{SLOT} 0.5 ms
120a
#0 #1
120b
SC-FDMA Symbol 142
Resource Element (RE) 140i
Subcarrier 15kHz 146
N^{UL}_{symb} x N^{RB}_{sc} REs in RB 130a
$k = N^{UL}_{RB} N^{RB}_{sc} - 1$
N^{UL}_{symb} SC-FDMA Symbols = 7 132
RB 130b
Resource Block (RB) 130i
RB 130m
RB 130n
$k = N^{UL}_{RB} N^{RB}_{sc}$ subcarriers 138
N^{RB}_{SC} subcarriers = 12 >= 180kHz 136
bit #0 150a
bit #1 150b
RE (k,l)
$l = 0$
$l = N^{UL}_{symb} - 1$
N^{UL}_{symb} x N^{RB}_{sc} REs in RB
$k = 0$

FIG. 4

UL-DL configuration for PDSCH HARQ timing reference		SCell SIB1 UL-DL configuration						
		0	1	2	3	4	5	6
PCell SIB1 UL-DL configuration	0	0	1	2	3	4	5	6
	1	1	1	2	4	4	5	1
	2	2	2	2	5	5	5	2
	3	3	4	5	3	4	5	3
	4	4	4	5	4	4	5	4
	5	5	5	5	5	5	5	5
	6	6	1	2	3	4	5	6

FIG. 5
(Table 4)

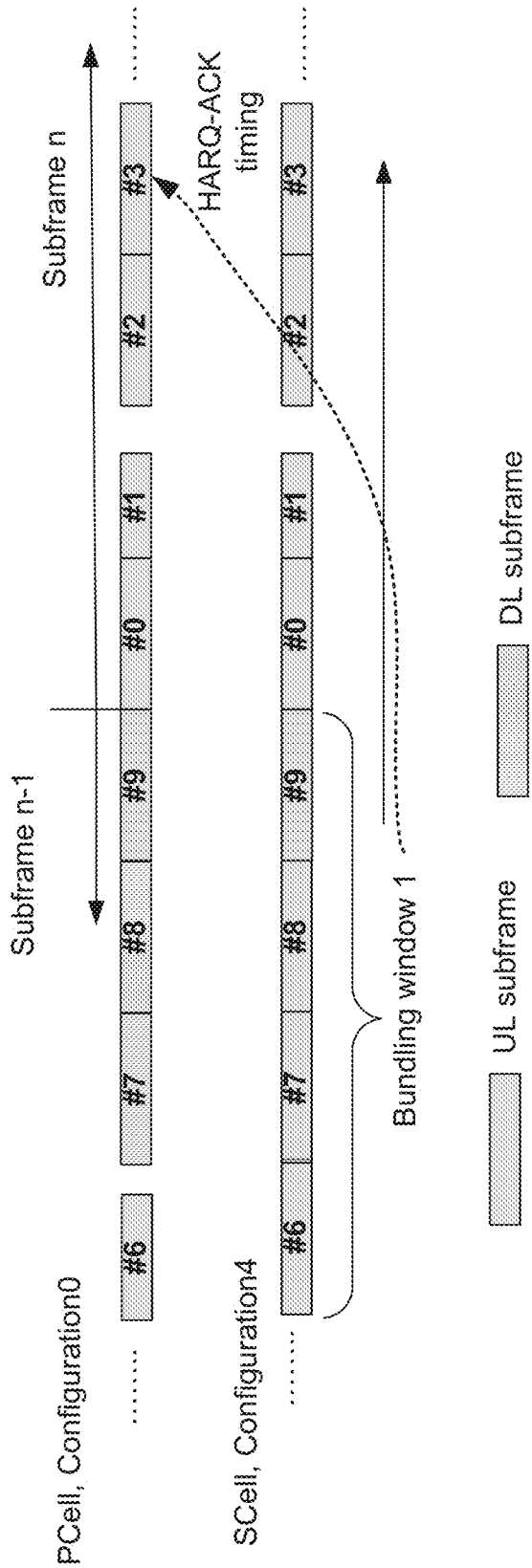

Subframe n
Subframe n-1
HARQ-ACK timing
PCell, Configuration0
SCell, Configuration4
#6
#7
#8
#9
#0
#1
#2
#3
Bundling window 1
UL subframe
DL subframe

FIG. 6

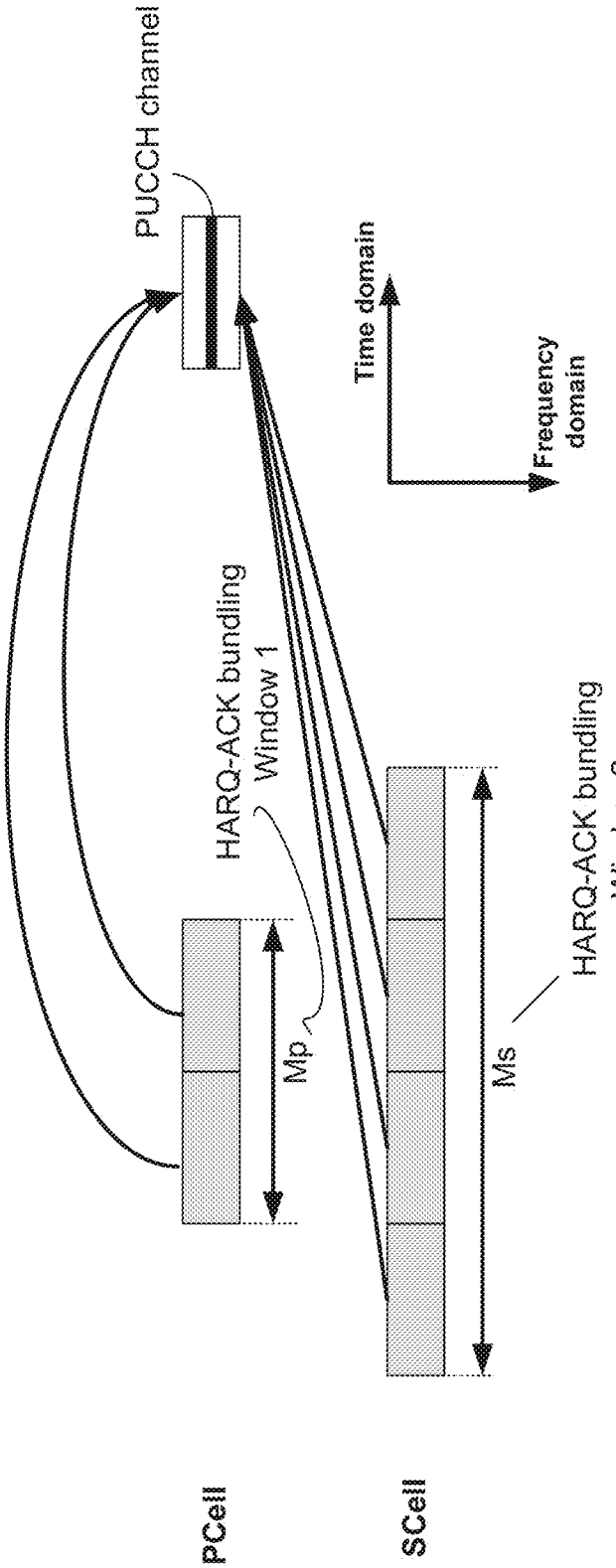

PUCCH channel
Time domain
Frequency domain
HARQ-ACK bundling Window 1
HARQ-ACK bundling Window 2
Mp
Ms
PCell
SCell

FIG. 7

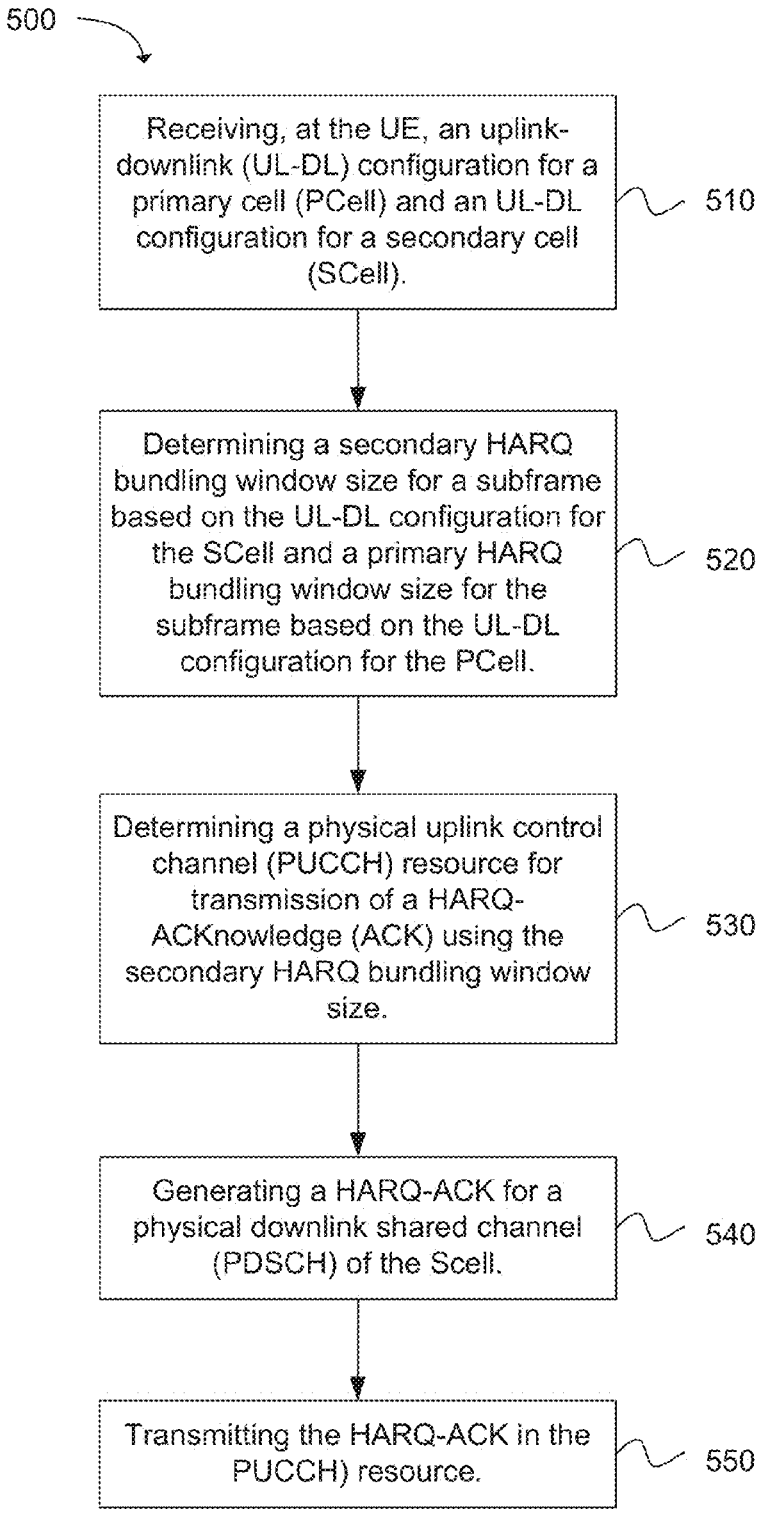

500
Receiving, at the UE, an uplink-downlink (UL-DL) configuration for a primary cell (PCell) and an UL-DL configuration for a secondary cell (SCell).
510
Determining a secondary HARQ bundling window size for a subframe based on the UL-DL configuration for the SCell and a primary HARQ bundling window size for the subframe based on the UL-DL configuration for the PCell.
520
Determining a physical uplink control channel (PUCCH) resource for transmission of a HARQ-ACKnowledge (ACK) using the secondary HARQ bundling window size.
530
Generating a HARQ-ACK for a physical downlink shared channel (PDSCH) of the Scell.
540
Transmitting the HARQ-ACK in the PUCCH) resource.
550

FIG. 8

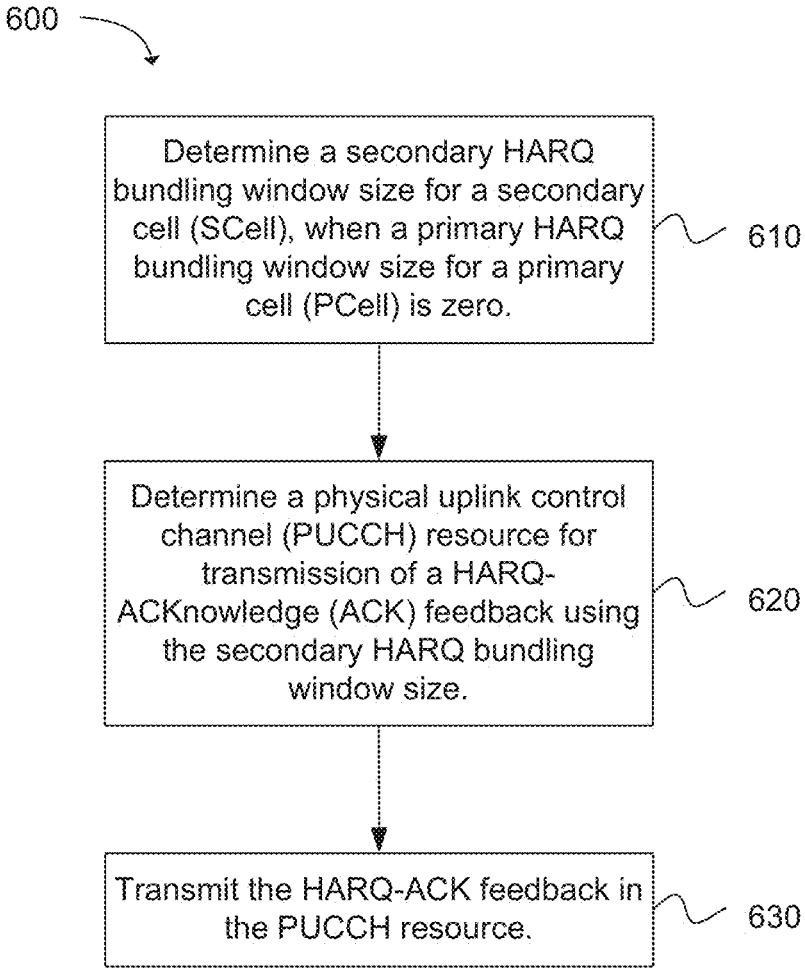

600
Determine a secondary HARQ bundling window size for a secondary cell (SCell), when a primary HARQ bundling window size for a primary cell (PCell) is zero.
610
Determine a physical uplink control channel (PUCCH) resource for transmission of a HARQ-ACKnowledge (ACK) feedback using the secondary HARQ bundling window size.
620
Transmit the HARQ-ACK feedback in the PUCCH resource.
630

FIG. 9

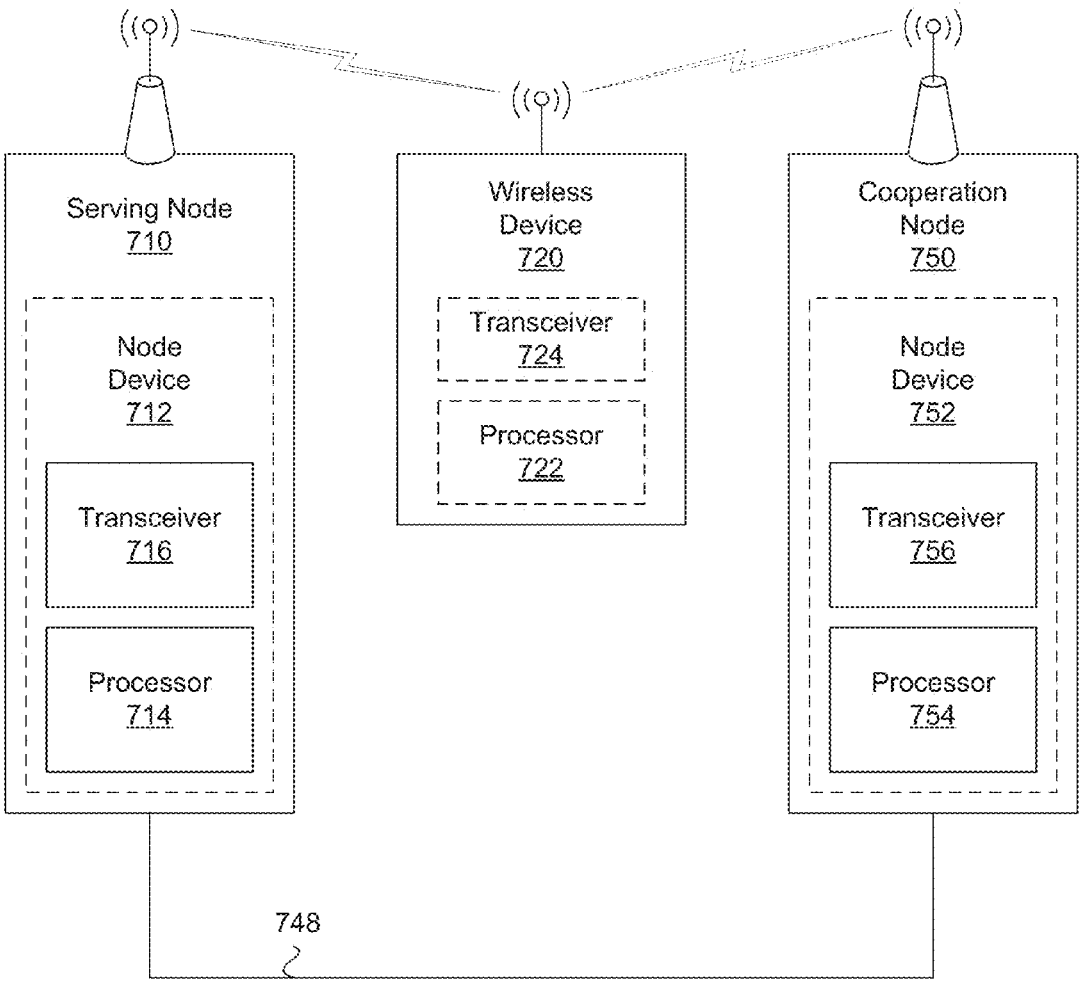

Serving Node
710
Node
Device
712
Transceiver
716
Processor
714
Wireless
Device
720
Transceiver
724
Processor
722
Cooperation
Node
750
Node
Device
752
Transceiver
756
Processor
754
748

FIG. 10

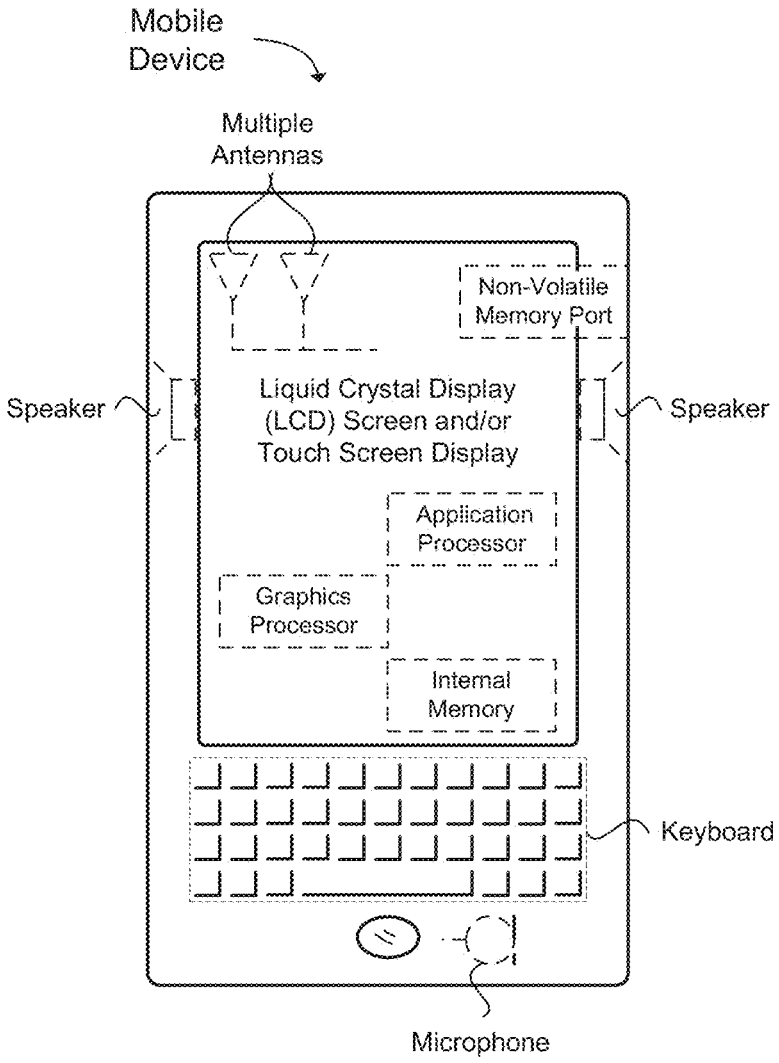

Mobile Device
Multiple Antennas
Non-Volatile Memory Port
Speaker
Liquid Crystal Display (LCD) Screen and/or Touch Screen Display
Speaker
Application Processor
Graphics Processor
Internal Memory
Keyboard
Microphone

FIG. 11

HARQ-ACK(0), HARQ-ACK(1)	$n_{PUCCH}^{(1)}$	$b(0), b(1)$
ACK, ACK	$n_{PUCCH,1}^{(1)}$	1, 1
ACK, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 1
NACK/DTX, ACK	$n_{PUCCH,1}^{(1)}$	0, 0
NACK/DTX, NACK	$n_{PUCCH,1}^{(1)}$	1, 0
NACK, DTX	$n_{PUCCH,0}^{(1)}$	1, 0
DTX, DTX	No transmission	

FIG. 12
(Table 5)

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	$n_{PUCCH}^{(1)}$	$b(0), b(1)$
ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	1, 1
ACK, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	1, 1
ACK, NACK/DTX, ACK	$n_{PUCCH,0}^{(1)}$	1, 1
ACK, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 1
NACK/DTX, ACK, ACK	$n_{PUCCH,2}^{(1)}$	1, 0
NACK/DTX, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	0, 0
NACK/DTX, NACK/DTX, ACK	$n_{PUCCH,2}^{(1)}$	0, 0
DTX, DTX, NACK	$n_{PUCCH,2}^{(1)}$	0, 1
DTX, NACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	1, 0
NACK, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 0
DTX, DTX, DTX	No transmission	

FIG. 13
(Table 6)

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	$n_{PUCCH}^{(1)}$	$b(0),b(1)$
ACK, ACK, ACK, ACK	$n_{PUCCH,1}^{(1)}$	1, 1
ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	1, 0
NACK/DTX,NACK/DTX,NACK,DTX	$n_{PUCCH,2}^{(1)}$	1, 1
ACK, ACK, NACK/DTX, ACK	$n_{PUCCH,1}^{(1)}$	1, 0
NACK, DTX, DTX, DTX	$n_{PUCCH,0}^{(1)}$	1, 0
ACK, ACK, NACK/DTX, NACK/DTX	$n_{PUCCH,1}^{(1)}$	1, 0
ACK, NACK/DTX, ACK, ACK	$n_{PUCCH,3}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, NACK/DTX, NACK	$n_{PUCCH,3}^{(1)}$	1, 1
ACK, NACK/DTX, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	0, 1
ACK, NACK/DTX, NACK/DTX, ACK	$n_{PUCCH,0}^{(1)}$	0, 1
ACK, NACK/DTX, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 1
NACK/DTX, ACK, ACK, ACK	$n_{PUCCH,3}^{(1)}$	0, 1
NACK/DTX, NACK, DTX, DTX	$n_{PUCCH,1}^{(1)}$	0, 0
NACK/DTX, ACK, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	1, 0
NACK/DTX, ACK, NACK/DTX, ACK	$n_{PUCCH,3}^{(1)}$	1, 0
NACK/DTX, ACK, NACK/DTX, NACK/DTX	$n_{PUCCH,1}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK, ACK	$n_{PUCCH,3}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	0, 0
NACK/DTX, NACK/DTX, NACK/DTX, ACK	$n_{PUCCH,3}^{(1)}$	0, 0
DTX, DTX, DTX, DTX	No transmission	

FIG. 14
(Table 7)

HARQ-ACK(0), HARQ-ACK(1)	$n^{(1)}_{PUCCH}$	$b(0)b(1)$
ACK, ACK	$n^{(1)}_{PUCCH,1}$	1, 0
ACK, NACK/DTX	$n^{(1)}_{PUCCH,0}$	1, 1
NACK/DTX, ACK	$n^{(1)}_{PUCCH,1}$	0, 1
NACK, NACK/DTX	$n^{(1)}_{PUCCH,0}$	0, 0
DTX, NACK/DTX	No Transmission	

FIG. 15
(Table 8)

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	$n^{(1)}_{PUCCH}$	$b(0)b(1)$
ACK, ACK, ACK	$n^{(1)}_{PUCCH,2}$	1, 1
ACK, ACK, NACK/DTX	$n^{(1)}_{PUCCH,1}$	1, 0
ACK, NACK/DTX, ACK	$n^{(1)}_{PUCCH,2}$	1, 0
ACK, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,0}$	1, 1
NACK/DTX, ACK, ACK	$n^{(1)}_{PUCCH,2}$	0, 1
NACK/DTX, ACK, NACK/DTX	$n^{(1)}_{PUCCH,1}$	0, 1
NACK/DTX, NACK/DTX, ACK	$n^{(1)}_{PUCCH,2}$	0, 0
NACK, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,0}$	0, 0
DTX, NACK/DTX, NACK/DTX	No Transmission	

FIG. 16
(Table 9)

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	$n^{(1)}_{PUCCH}$	$b(0)b(1)$
ACK, ACK, ACK, ACK	$n^{(1)}_{PUCCH,1}$	1, 1
ACK, ACK, ACK, NACK/DTX	$n^{(1)}_{PUCCH,2}$	1, 1
ACK, ACK, NACK/DTX, ACK	$n^{(1)}_{PUCCH,0}$	1, 0
ACK, ACK, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,1}$	1, 0
ACK, NACK/DTX, ACK, ACK	$n^{(1)}_{PUCCH,3}$	1, 1
ACK, NACK/DTX, ACK, NACK/DTX	$n^{(1)}_{PUCCH,2}$	1, 0
ACK, NACK/DTX, NACK/DTX, ACK	$n^{(1)}_{PUCCH,0}$	0, 1
ACK, NACK/DTX, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,0}$	1, 1
NACK/DTX, ACK, ACK, ACK	$n^{(1)}_{PUCCH,1}$	0, 0
NACK/DTX, ACK, ACK, NACK/DTX	$n^{(1)}_{PUCCH,2}$	0, 1
NACK/DTX, ACK, NACK/DTX, ACK	$n^{(1)}_{PUCCH,3}$	1, 0
NACK/DTX, ACK, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,1}$	0, 1
NACK/DTX, NACK/DTX, ACK, ACK	$n^{(1)}_{PUCCH,3}$	0, 1
NACK/DTX, NACK/DTX, ACK, NACK/DTX	$n^{(1)}_{PUCCH,2}$	0, 0
NACK/DTX, NACK/DTX, NACK/DTX, ACK	$n^{(1)}_{PUCCH,3}$	0, 0
NACK, NACK/DTX, NACK/DTX, NACK/DTX	$n^{(1)}_{PUCCH,0}$	0, 0
DTX, NACK/DTX, NACK/DTX, NACK/DTX	No Transmission	

FIG. 17
(Table 10)

Primary Cell	Secondary Cell	Resource	Constellation	RM Code Input Bits
HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	$n_{PUCCH}^{(1)}$	$b(0), b(1)$	$o(0), o(1), o(2), o(3)$
ACK, ACK, ACK	ACK, ACK, ACK	$n_{PUCCH,1}^{(1)}$	1, 1	1,1,1,1
ACK, ACK, NACK/DTX	ACK, ACK, ACK	$n_{PUCCH,1}^{(1)}$	0, 0	1,0,1,1
ACK, NACK/DTX, any	ACK, ACK, ACK	$n_{PUCCH,3}^{(1)}$	1, 1	0,1,1,1
NACK/DTX, any, any	ACK, ACK, ACK	$n_{PUCCH,3}^{(1)}$	0, 1	0,0,1,1
ACK, ACK, ACK	ACK, ACK, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 0	1,1,1,0
ACK, ACK, NACK/DTX	ACK, ACK, NACK/DTX	$n_{PUCCH,3}^{(1)}$	1, 0	1,0,1,0
ACK, NACK/DTX, any	ACK, ACK, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 1	0,1,1,0
NACK/DTX, any, any	ACK, ACK, NACK/DTX	$n_{PUCCH,3}^{(1)}$	0, 0	0,0,1,0
ACK, ACK, ACK	ACK, NACK/DTX, any	$n_{PUCCH,2}^{(1)}$	1, 1	1, 1, 0, 1
ACK, ACK, NACK/DTX	ACK, NACK/DTX, any	$n_{PUCCH,2}^{(1)}$	0, 1	1, 0, 0, 1
ACK, NACK/DTX, any	ACK, NACK/DTX, any	$n_{PUCCH,2}^{(1)}$	1, 0	0, 1, 0, 1
NACK/DTX, any, any	ACK, NACK/DTX, any	$n_{PUCCH,2}^{(1)}$	0, 0	0, 0, 0, 1
ACK, ACK, ACK	NACK/DTX, any, any	$n_{PUCCH,1}^{(1)}$	1, 0	1, 1, 0, 0
ACK, ACK, NACK/DTX	NACK/DTX, any, any	$n_{PUCCH,1}^{(1)}$	0, 1	1, 0, 0, 0
ACK, NACK/DTX, any	NACK/DTX, any, any	$n_{PUCCH,0}^{(1)}$	1, 1	0, 1, 0, 0
NACK, any, any	NACK/DTX, any, any	$n_{PUCCH,0}^{(1)}$	0, 0	0, 0, 0, 0
DTX, any, any	NACK/DTX, any, any	No Transmission		0, 0, 0, 0

FIG. 18
(Table 11)

Primary Cell	Secondary Cell	Resource	Constellation	RM Code Input Bits
HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	$n_{PUCCH}^{(1)}$	$b(0),b(1)$	$o(0),o(1),o(2),o(3)$
ACK, ACK, ACK, NACK/DTX	ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	1, 1	1, 1, 1, 1
ACK, ACK, NACK/DTX, any	ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	0, 0	1, 0, 1, 1
ACK, DTX, DTX, DTX	ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,3}^{(1)}$	1, 1	0, 1, 1, 1
ACK, ACK, ACK, ACK	ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,3}^{(1)}$	1, 1	0, 1, 1, 1
NACK/DTX, any, any, any	ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,3}^{(1)}$	0, 1	0, 0, 1, 1
(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,3}^{(1)}$	0, 1	0, 0, 1, 1
ACK, ACK, ACK, NACK/DTX	ACK, ACK, NACK/DTX, any	$n_{PUCCH,0}^{(1)}$	1, 0	1, 1, 1, 0
ACK, ACK, NACK/DTX, any	ACK, ACK, NACK/DTX, any	$n_{PUCCH,3}^{(1)}$	1, 0	1, 0, 1, 0
ACK, DTX, DTX, DTX	ACK, ACK, NACK/DTX, any	$n_{PUCCH,0}^{(1)}$	0, 1	0, 1, 1, 0
ACK, ACK, ACK, ACK	ACK, ACK, NACK/DTX, any	$n_{PUCCH,0}^{(1)}$	0, 1	0, 1, 1, 0
NACK/DTX, any, any, any	ACK, ACK, NACK/DTX, any	$n_{PUCCH,3}^{(1)}$	0, 0	0, 0, 1, 0
(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	ACK, ACK, NACK/DTX, any	$n_{PUCCH,3}^{(1)}$	0, 0	0, 0, 1, 0
ACK, ACK, ACK, NACK/DTX	ACK, DTX, DTX, DTX	$n_{PUCCH,2}^{(1)}$	1, 1	1, 1, 0, 1
ACK, ACK, ACK, NACK/DTX	ACK, ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	1, 1	1, 1, 0, 1
ACK, ACK, NACK/DTX, any	ACK, DTX, DTX, DTX	$n_{PUCCH,2}^{(1)}$	0, 1	1, 0, 0, 1
ACK, ACK, NACK/DTX, any	ACK, ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	0, 1	1, 0, 0, 1
ACK, DTX, DTX, DTX	ACK, DTX, DTX, DTX	$n_{PUCCH,2}^{(1)}$	1, 0	0, 1, 0, 1
ACK, DTX, DTX, DTX	ACK, ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	1, 0	0, 1, 0, 1
ACK, ACK, ACK, ACK	ACK, DTX, DTX, DTX	$n_{PUCCH,2}^{(1)}$	1, 0	0, 1, 0, 1
ACK, ACK, ACK, ACK	ACK, ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	1, 0	0, 1, 0, 1
NACK/DTX, any, any, any	ACK, DTX, DTX, DTX	$n_{PUCCH,2}^{(1)}$	0, 0	0, 0, 0, 1
NACK/DTX, any, any, any	ACK, ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	0, 0	0, 0, 0, 1
(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	ACK, DTX, DTX, DTX	$n_{PUCCH,2}^{(1)}$	0, 0	0, 0, 0, 1
(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	ACK, ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	0, 0	0, 0, 0, 1
ACK, ACK, ACK, NACK/DTX	NACK/DTX, any, any, any	$n_{PUCCH,1}^{(1)}$	1, 0	1, 1, 0, 0
ACK, ACK, ACK, NACK/DTX	(ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX)	$n_{PUCCH,1}^{(1)}$	1, 0	1, 1, 0, 0

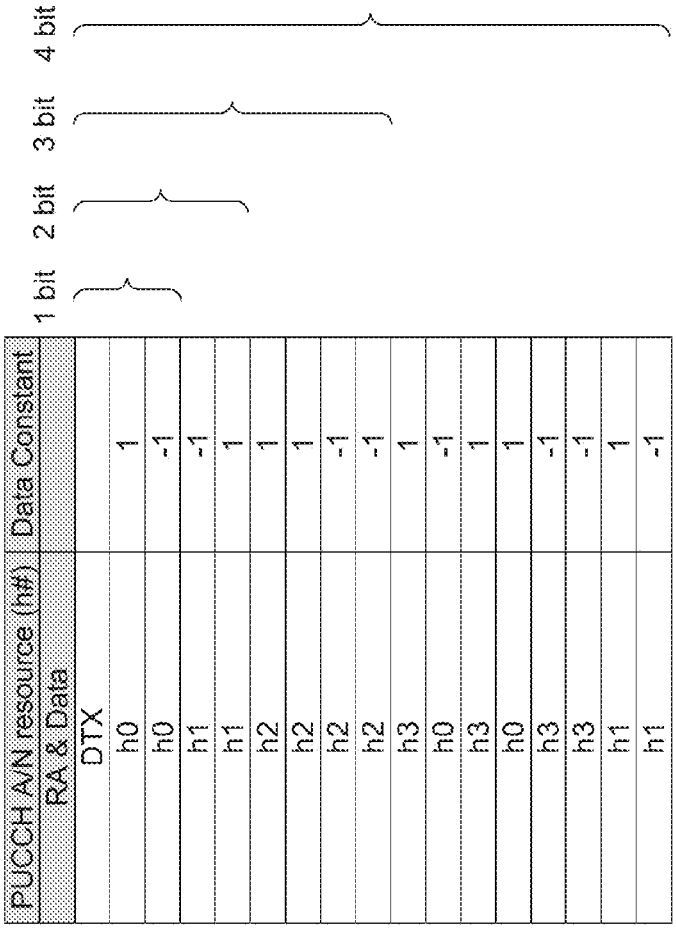
FIG. 19
(Table 12)

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	Mapped state
'D, any, any, any' or no DL assignment is received.	D, D
'A, D, D, D'	A, N
'A, A, N/D, any'	N, A
'A, A, A, N/D'	A, A
'A, A, A, A'	A, N
'N, any, any, any' or 'A, D/N, any, any except for A, D, D, D'	N, N

FIG. 20
(Table 13)

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	Mapped state
ACK, ACK, ACK	ACK, ACK
ACK, ACK, NACK/DTX	NACK/DTX, ACK
ACK, NACK/DTX, any	ACK, NACK/DTX
NACK/DTX, any, any	NACK/DTX, NACK/DTX

FIG. 21
(Table 14)



PUCCH A/N resource (h#)		Data Constant
RA & Data		
DTX		
h0		1
h0		-1
h1		-1
h1		1
h2		1
h2		1
h2		-1
h2		-1
h3		1
h0		-1
h3		1
h0		1
h3		-1
h3		-1
h1		1
h1		-1

1 bit 2 bit 3 bit 4 bit

PCC	PCC/SCC	SCC	SCC
b0	b1	b2	b3
D	N/D	N/D	N/D
N	N/D	N/D	N/D
A	N/D	N/D	N/D
N/D	A	N/D	N/D
A	A	N/D	N/D
N/D	N/D	A	N/D
A	N/D	A	N/D
N/D	A	A	N/D
A	A	A	N/D
N/D	N/D	N/D	A
A	N/D	N/D	A
N/D	A	N/D	A
A	A	N/D	A
N/D	N/D	A	A
A	N/D	A	A
N/D	A	A	A
A	A	A	A

FIG. 22
(Table 15)

Index	M_1=2	M_2 = 3 or M_1=3	M_2=4
	HARQ-ACK(0), HARQ-ACK(1)	HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK (2)	HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK (2), HARQ-ACK(3)
0	ACK, NACK/DTX →	ACK, NACK/DTX, any →	ACK, DTX,DTX,DTX
1	NACK/DTX, ACK →	ACK,ACK, NACK/DTX →	ACK,ACK, NACK/DTX, any
2	ACK,ACK →	ACK,ACK,ACK →	ACK,ACK,ACK, NACK/DTX
3	DTX,DTX/NACK →	DTX, any, any →	DTX, any, any, any
4	NACK,NACK/DTX →	NACK/DTX, any, any →	N, any, any, any

Sharing the same mapped PUCCH state after channel selection

FIG. 23
(Table 16)

Value of 'TPC command for PUCCH'	$n_{PUCCH}^{(1,p)}$
'00'	The first PUCCH resource value configured by the higher layers
'01'	The second PUCCH resource value configured by the higher layers
'10'	The third PUCCH resource value configured by the higher layers
'11'	The fourth PUCCH resource value configured by the higher layers

FIG. 24
(Table 17)

HYBRID AUTOMATIC REPEAT REQUEST (HARQ) MAPPING FOR CARRIER AGGREGATION (CA)

RELATED APPLICATIONS

This application claims the benefit of and hereby incorporates by reference U.S. Provisional Patent Application Ser. No. 61/707,784, filed Sep. 28, 2012.

BACKGROUND

Wireless mobile communication technology uses various standards and protocols to transmit data between a node (e.g., a transmission station) and a wireless device (e.g., a mobile device). Some wireless devices communicate using orthogonal frequency-division multiple access (OFDMA) in a downlink (DL) transmission and single carrier frequency division multiple access (SC-FDMA) in an uplink (UL) transmission. Standards and protocols that use orthogonal frequency-division multiplexing (OFDM) for signal transmission include the third generation partnership project (3GPP) long term evolution (LTE), the Institute of Electrical and Electronics Engineers (IEEE) 802.16 standard (e.g., 802.16e, 802.16m), which is commonly known to industry groups as WiMAX (Worldwide interoperability for Microwave Access), and the IEEE 802.11 standard, which is commonly known to industry groups as WiFi.

In 3GPP radio access network (RAN) LTE systems, the node can be a combination of Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Node Bs (also commonly denoted as evolved Node Bs, enhanced Node Bs, eNodeBs, or eNBs) and Radio Network Controllers (RNCs), which communicates with the wireless device, known as a user equipment (UE). The downlink (DL) transmission can be a communication from the node (e.g., eNodeB) to the wireless device (e.g., UE), and the uplink (UL) transmission can be a communication from the wireless device to the node.

In LTE, data can be transmitted from the eNodeB to the UE via a physical downlink shared channel (PDSCH). A physical uplink control channel (PUCCH) can be used to acknowledge that data was received. Downlink and uplink channels or transmissions can use time-division duplexing (TDD) or frequency-division duplexing (FDD). Time-division duplexing (TDD) is an application of time-division multiplexing (TDM) to separate downlink and uplink signals (or separate signals to a UE or from the UE in D2D communication). In TDD, downlink signals and uplink signals may be carried on a same carrier frequency (i.e., shared carrier frequency) where the downlink signals use a different time interval from the uplink signals, so the downlink signals and the uplink signals do not generate interference for each other. TDM is a type of digital multiplexing in which two or more bit streams or signals, such as a downlink or uplink, are transferred apparently simultaneously as subchannels in one communication channel, but are physically transmitted on different resources. In frequency-division duplexing (FDD), an uplink transmission and a downlink transmission (or a transmission to and from a UE in D2D communication) can operate using different frequency carriers (i.e. separate carrier frequency for each transmission direction). In FDD, interference can be avoided because the downlink signals use a different frequency carrier from the uplink signals.

BRIEF DESCRIPTION OF THE DRAWINGS

Features and advantages of the disclosure will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings, which together illustrate, by way of example, features of the disclosure; and, wherein:

FIG. **1** illustrates a block diagram of various component carrier (CC) bandwidths in accordance with an example;

FIG. **2**A illustrates a block diagram of multiple contiguous component carriers in accordance with an example;

FIG. **2**B illustrates a block diagram of intra-band non-contiguous component carriers in accordance with an example;

FIG. **2**C illustrates a block diagram of inter-band non-contiguous component carriers in accordance with an example;

FIG. **3**A illustrates a block diagram of a symmetric-asymmetric carrier aggregation configuration in accordance with an example;

FIG. **3**B illustrates a block diagram of an asymmetric-symmetric carrier aggregation configuration in accordance with an example;

FIG. **4** illustrates a block diagram of uplink radio frame resources (e.g., a resource grid) in accordance with an example;

FIG. **5** (i.e., Table 4) illustrates a table of an UpLink-DownLink (UL-DL) configuration number of Physical Downlink Shared CHannel (PDSCH) Hybrid Automatic Retransmission re-Quest-ACKnowledge (HARQ-ACK) timing reference for a Secondary Cell (SCell) in accordance with an example;

FIG. **6** illustrates variable hybrid automatic repeat request-acknowledgement (HARQ-ACK) bundling window sizes for a Primary Cell (PCell) and a Secondary Cell (SCell) for inter-band time division duplex (TDD) carrier aggregation (CA) (e.g., different UL-DL configurations) in accordance with an example;

FIG. **7** illustrates different hybrid automatic repeat request-acknowledgement (HARQ-ACK) bundling windows in time division duplex (TDD) inter-band carrier aggregation (CA) scenario in accordance with an example;

FIG. **8** depicts a flow chart of a method for hybrid automatic retransmission re-quest (HARQ) bundling used in carrier aggregation (CA) at a user equipment (UE) in accordance with an example;

FIG. **9** depicts functionality of computer circuitry of a user equipment (UE) operable to dynamically alter hybrid automatic retransmission re-quest (HARQ) mapping for carrier aggregation (CA) in accordance with an example;

FIG. **10** illustrates a block diagram of a serving node, a coordination node, and wireless device (e.g., UE) in accordance with an example;

FIG. **11** illustrates a diagram of a wireless device (e.g., UE) in accordance with an example;

FIG. **12** (i.e., Table 5) illustrates a table of a transmission of hybrid automatic repeat request-acknowledgement (HARQ-ACK) multiplexing for a bundling window size of M=2 (i.e., 3GPP LTE standard Release 11 Technical Specification (TS) 36.213 Table 10.1.3-2) in accordance with an example;

FIG. **13** (i.e., Table 6) illustrates a table of a transmission of hybrid automatic repeat request-acknowledgement (HARQ-ACK) multiplexing for a bundling window size of M=3 (i.e., 3GPP LTE standard Release 11 Technical Specification (TS) 36.213 Table 10.1.3-3) in accordance with an example;

FIG. **14** (i.e., Table 7) illustrates a table of a transmission of hybrid automatic repeat request-acknowledgement (HARQ-ACK) multiplexing for a bundling window size of

M=4 (i.e., 3GPP LTE standard Release 11 Technical Specification (TS) 36.213 Table 10.1.3-4) in accordance with an example;

FIG. **15** (i.e., Table 8) illustrates a table of a transmission of hybrid automatic repeat request-acknowledgement (HARQ-ACK) multiplexing for a bundling window size of M=2 (i.e., 3GPP LTE standard Release 11 Technical Specification (TS) 36.213 Table 10.1.3-5) in accordance with an example;

FIG. **16** (i.e., Table 9) illustrates a table of a transmission of hybrid automatic repeat request-acknowledgement (HARQ-ACK) multiplexing for a bundling window size of M=3 (i.e., 3GPP LTE standard Release 11 Technical Specification (TS) 36.213 Table 10.1.3-6) in accordance with an example;

FIG. **17** (i.e., Table 10) illustrates a table of a transmission of hybrid automatic repeat request-acknowledgement (HARQ-ACK) multiplexing for a bundling window size of M=4 (i.e., 3GPP LTE standard Release 11 Technical Specification (TS) 36.213 Table 10.1.3-7) in accordance with an example;

FIG. **18** (i.e., Table 11) illustrates a table of a transmission of hybrid automatic repeat request-acknowledgement (HARQ-ACK) multiplexing for a bundling window size of M=3 (i.e., 3GPP LTE standard Release 11 Technical Specification (TS) 36.213 Table 10.1.3.2-5) in accordance with an example; and

FIG. **19** (i.e., Table 12) illustrates a table of a transmission of hybrid automatic repeat request-acknowledgement (HARQ-ACK) multiplexing for a bundling window size of M=3 (i.e., 3GPP LTE standard Release 11 Technical Specification (TS) 36.213 Table 10.1.3.2-6) in accordance with an example.

FIG. **20** (i.e., Table 13) illustrates a table of a transmission of hybrid automatic repeat request-acknowledgement (HARQ-ACK) multiplexing for a bundling window size of M=4 in accordance with an example;

FIG. **21** (i.e., Table 14) illustrates a table of a transmission of hybrid automatic repeat request-acknowledgement (HARQ-ACK) multiplexing for a bundling window size of M=3 in accordance with an example;

FIG. **22** (i.e., Table 15) illustrates a table of a hybrid automatic repeat request-acknowledgement (HARQ-ACK) mapping table for physical uplink control channel (PUCCH) format 1b with channel selection (CS) in accordance with an example;

FIG. **23** (i.e., Table 16) illustrates a table of a hybrid automatic repeat request-acknowledgement (HARQ-ACK) look-up mapping table for different uplink-downlink (UL-DL) configurations of inter-band time division duplex (TDD) carrier aggregation (CA) in accordance with an example; and

FIG. **24** (i.e., Table 17) illustrates a table of a physical uplink control channel (PUCCH) resource value according to acknowledgement (ACK)/negative ACK (ACK/NACK) Resource Indicator (ARI) (i.e., 3GPP LTE standard Release 11 Technical Specification (TS) 36.213 Table 9.2-2) in accordance with an example.

Reference will now be made to the exemplary embodiments illustrated, and specific language will be used herein to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended.

DETAILED DESCRIPTION

Before the present invention is disclosed and described, it is to be understood that this invention is not limited to the particular structures, process steps, or materials disclosed herein, but is extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular examples only and is not intended to be limiting. The same reference numerals in different drawings represent the same element. Numbers provided in flow charts and processes are provided for clarity in illustrating steps and operations and do not necessarily indicate a particular order or sequence.

All tables cited herein from the 3GPP LTE standard are provided from Release 11 of the 3GPP LTE standard, unless otherwise noted.

Example Embodiments

An initial overview of technology embodiments is provided below and then specific technology embodiments are described in further detail later. This initial summary is intended to aid readers in understanding the technology more quickly but is not intended to identify key features or essential features of the technology nor is it intended to limit the scope of the claimed subject matter.

An increase in the amount of wireless data transmission has created congestion in wireless networks using licensed spectrum to provide wireless communication services for wireless devices, such as smart phones and tablet devices. The congestion is especially apparent in high density and high use locations such as urban locations and universities.

One technique for providing additional bandwidth capacity to wireless devices is through the use carrier aggregation of multiple smaller bandwidths to form a virtual wideband channel at a wireless device (e.g., UE). In carrier aggregation (CA) multiple component carriers (CC) can be aggregated and jointly used for transmission to/from a single terminal. Carriers can be signals in permitted frequency domains onto which information is placed. The amount of information that can be placed on a carrier can be determined by the aggregated carrier's bandwidth in the frequency domain. The permitted frequency domains are often limited in bandwidth. The bandwidth limitations can become more severe when a large number of users are simultaneously using the bandwidth in the permitted frequency domains.

FIG. **1** illustrates a carrier bandwidth, signal bandwidth, or a component carrier (CC) that can be used by the wireless device. For example, the LTE CC bandwidths can include: 1.4 MHz 210, 3 MHz 212, 5 MHz 214, 10 MHz 216, 15 MHz 218, and 20 MHz 220. The 1.4 MHz CC can include 6 resource blocks (RBs) comprising 72 subcarriers. The 3 MHz CC can include 15 RBs comprising 180 subcarriers. The 5 MHz CC can include 25 RBs comprising 300 subcarriers. The 10 MHz CC can include 50 RBs comprising 600 subcarriers. The 15 MHz CC can include 75 RBs comprising 900 subcarriers. The 20 MHz CC can include 100 RBs comprising 1200 subcarriers.

Carrier aggregation (CA) enables multiple carrier signals to be simultaneously communicated between a user's wireless device and a node. Multiple different carriers can be used. In some instances, the carriers may be from different permitted frequency domains. Carrier aggregation provides a broader choice to the wireless devices, enabling more bandwidth to be obtained. The greater bandwidth can be used to communicate bandwidth intensive operations, such as streaming video or communicating large data files.

FIG. **2**A illustrates an example of carrier aggregation of continuous carriers. In the example, three carriers are contiguously located along a frequency band. Each carrier can be referred to as a component carrier. In a continuous type

of system, the component carriers are located adjacent one another and can be typically located within a single frequency band (e.g., band A). A frequency band can be a selected frequency range in the electromagnetic spectrum. Selected frequency bands are designated for use with wireless communications such as wireless telephony. Certain frequency bands are owned or leased by a wireless service provider. Each adjacent component carrier may have the same bandwidth, or different bandwidths. A bandwidth is a selected portion of the frequency band. Wireless telephony has traditionally been conducted within a single frequency band. In contiguous carrier aggregation, only one fast Fourier transform (FFT) module and/or one radio frontend may be used. The contiguous component carriers can have similar propagation characteristics which can utilize similar reports and/or processing modules.

FIGS. **2**B-**2**C illustrates an example of carrier aggregation of non-continuous component carriers. The non-continuous component carriers may be separated along the frequency range. Each component carrier may even be located in different frequency bands. Non-contiguous carrier aggregation can provide aggregation of a fragmented spectrum. Intra-band (or single-band) non-contiguous carrier aggregation provides non-contiguous carrier aggregation within a same frequency band (e.g., band A), as illustrated in FIG. **2**B. Inter-band (or multi-band) non-contiguous carrier aggregation provides non-contiguous carrier aggregation within different frequency bands (e.g., bands A, B, or C), as illustrated in FIG. **2**C. The ability to use component carriers in different frequency bands can enable more efficient use of available bandwidth and increases the aggregated data throughput.

Network symmetric (or asymmetric) carrier aggregation can be defined by a number of downlink (DL) and uplink (UL) component carriers offered by a network in a sector. UE symmetric (or asymmetric) carrier aggregation can be defined by a number of downlink (DL) and uplink (UL) component carriers configured for a UE. The number of DL CCs may be at least the number of UL CCs. A system information block type 2 (SIB2) can provide specific linking between the DL and the UL. FIG. **3**A illustrates a block diagram of a symmetric-asymmetric carrier aggregation configuration, where the carrier aggregation is symmetric between the DL and UL for the network and asymmetric between the DL and UL for the UE. FIG. **3**B illustrates a block diagram of an asymmetric-symmetric carrier aggregation configuration, where the carrier aggregation is asymmetric between the DL and UL for the network and symmetric between the DL and UL for the UE.

For each UE, a CC can be defined as a primary cell (PCell). Different UEs may not necessarily use a same CC as their PCell. The PCell can be regarded as an anchor carrier for the UE and the PCell can thus be used for control signaling functionalities, such as radio link failure monitoring, hybrid automatic repeat request-acknowledgement (HARQ-ACK), and PUCCH resource allocations (RA). If more than one CC is configured for a UE, the additional CCs can be denoted as secondary cells (SCells) for the UE.

A component carrier can be used to carry channel information via a radio frame structure transmitted on the physical (PHY) layer in a uplink transmission between a node (e.g., eNodeB) and the wireless device (e.g., UE) using a generic long term evolution (LTE) frame structure, as illustrated in FIG. **4**. While an LTE frame structure is illustrated, a frame structure for an IEEE 802.16 standard (WiMax), an IEEE 802.11 standard (WiFi), or another type of communication standard using SC-FDMA or OFDMA may also be used.

FIG. **4** illustrates an uplink radio frame structure. A similar structure can be used for a downlink radio frame structure using OFDMA. In the example, a radio frame **100** of a signal used to transmit control information or data can be configured to have a duration, T_f, of 10 milliseconds (ms). Each radio frame can be segmented or divided into ten subframes **110***i* that are each 1 ms long. Each subframe can be further subdivided into two slots **120***a* and **120***b*, each with a duration, T_{slot}, of 0.5 ms. Each slot for a component carrier (CC) used by the wireless device and the node can include multiple resource blocks (RBs) **130***a*, **130***b*, **130***i*, **130***m*, and **130***n* based on the CC frequency bandwidth. Each RB (physical RB or PRB) **130***i* can include 12-15 kHz subcarriers **136** (on the frequency axis) and 6 or 7 SC-FDMA symbols **132** (on the time axis) per subcarrier. The RB can use seven SC-FDMA symbols if a short or normal cyclic prefix is employed. The RB can use six SC-FDMA symbols if an extended cyclic prefix is used. The resource block can be mapped to 84 resource elements (REs) **140***i* using short or normal cyclic prefixing, or the resource block can be mapped to 72 REs (not shown) using extended cyclic prefixing. The RE can be a unit of one SC-FDMA symbol **142** by one subcarrier (i.e., 15 kHz) **146**. Each RE can transmit two bits **150***a* and **150***b* of information in the case of quadrature phase-shift keying (QPSK) modulation. Other types of modulation may be used, such as 16 quadrature amplitude modulation (QAM) or 64 QAM to transmit a greater number of bits in each RE, or bi-phase shift keying (BPSK) modulation to transmit a lesser number of bits (a single bit) in each RE. The RB can be configured for an uplink transmission from the wireless device to the node.

An uplink signal or channel can include data on a Physical Uplink Shared CHannel (PUSCH) or control information on a Physical Uplink Control CHannel (PUCCH). In LTE, the uplink physical channel (PUCCH) carrying uplink control information (UCI) can include channel state information (CSI) reports, Hybrid Automatic Retransmission reQuest (HARQ) ACKnowledgment/Negative ACKnowledgment (ACK/NACK) and uplink scheduling requests (SR).

The wireless device (e.g., UE) can provide HARQ-ACK feedback for a PDSCH using a PUCCH. The PUCCH can support multiple formats (i.e., PUCCH format) with various modulation and coding schemes (MCS), as shown for LTE in Table 1. Similar information to Table 1 can be shown in 3GPP LTE standard Release 11 (e.g., V11.1.0 (2012-12)) Technical Specification (TS) 36.211 Table 5.4-1. For example, PUCCH format 1b can be used to convey a two-bit HARQ-ACK, which can be used for carrier aggregation.

TABLE 1

PUCCH format	Modulation scheme	Number of bits per subframe, M_{bit}
1	N/A	N/A
1a	BPSK	1
1b	QPSK	2
2	QPSK	20
2a	QPSK + BPSK	21
2b	QPSK + QPSK	22
3	QPSK	48

Legacy LTE TDD can support asymmetric UL-DL allocations by providing seven different semi-statically configured uplink-downlink configurations. Table 2 illustrates

seven UL-DL configurations used in LTE, where "D" represents a downlink subframe, "S" represents a special subframe, and "U" represents an uplink subframe. In an example, the special subframe can operate or be treated as a downlink subframe. Similar information to Table 2 can be shown in 3GPP LTE TS 36.211 Table 4.2-2.

TABLE 2

Uplink-downlink	Subframe number									
configuration	0	1	2	3	4	5	6	7	8	9
0	D	S	U	U	U	D	S	U	U	U
1	D	S	U	U	D	D	S	U	U	D
2	D	S	U	D	D	D	S	U	D	D
3	D	S	U	U	U	D	D	D	D	D
4	D	S	U	U	D	D	D	D	D	D
5	D	S	U	D	D	D	D	D	D	D
6	D	S	U	U	U	D	S	U	U	D

As illustrated by Table 2, UL-DL configuration 0 can include 6 uplink subframes in subframes 2, 3, 4, 7, 8, and 9, and 4 downlink and special subframes in subframes 0, 1, 5, and 6; and UL-DL configuration 5 can include one uplink subframe in subframe 2, and 9 downlink and special subframes in subframes 0, 1, and 3-9. Each uplink subframe n can be associated with a downlink subframe based on the uplink-downlink configuration, where each uplink subframe n can have a downlink association set index $K \in \{k_0, k_1, \ldots k_{M-1}\}$ where M is defined as the number of elements in set K, as illustrated by Table 3. Similar information to Table 3 can be shown in 3GPP LTE TS 36.213 Table 10.1.3.1-1.

As an underlying requirement in some examples, cells of the network can change UL-DL (TDD) configurations synchronously in order to avoid the interference. However, such a requirement can constrain the traffic management capabilities in different cells of the network. The legacy LTE TDD set of configurations can provide DL subframe allocations in the range between 40% and 90%, as shown in Table 2. The UL and DL subframes allocation within a radio frame can be reconfigured through system information broadcast signaling (e.g., system information block [SIB]). Hence, the UL-DL allocation once configured can be expected to vary semi-statically.

A property of TDD is that a number of UL and DL subframes can be different as shown in Table 2 and often the number of DL subframes can be more than the number of UL subframes for a radio frame. In configurations where more DL subframes are used than UL subframes, multiple DL subframes can be associated with one single UL subframe for the transmission of a corresponding control signals. A configuration-specific HARQ-ACK timing relationship can be defined (e.g., 3GPP LTE standard Release 11 (e.g., V11.1.0 (2012-12)) TS 36.213 Table 10.1.3.1-1 or Table 3). If a UE is scheduled in a multiple of DL subframes, which can be associated with one UL subframe, the UE can transmit multiple ACK/NAK (ACK/NACK) bits in that UL subframe. A number of DL subframes with HARQ-ACK feedback on one single UL subframe can comprise one bundling window.

As shown in FIG. **6**, the subframes 6, 7, 8, and 9 of a previous radio frame can comprise one bundling window (e.g., bundling window 1) on a SCell according a predefined

TABLE 3

UL-DL	Subframe n									
Configuration	0	1	2	3	4	5	6	7	8	9
0	—	—	6	—	4	—	—	6	—	4
1	—	—	7, 6	4	—	—	—	7, 6	4	—
2	—	—	8, 7, 4, 6	—	—	—	—	8, 7, 4, 6	—	—
3	—	—	7, 6, 11	6, 5	5, 4	—	—	—	—	—
4	—	—	12, 8, 7, 11	6, 5, 4, 7	—	—	—	—	—	—
5	—	—	13, 12, 9, 8, 7, 5, 4, 11, 6	—	—	—	—	—	—	—
6	—	—	7	7	5	—	—	7	7	—

The Table 3 shows examples of downlink subframe bundling in an uplink subframe handling ACK/NACK feedback for certain downlink subframe(s). For example, in uplink-downlink configuration 4, uplink subframe 2 (subframe n) handles ACK/NACK feedback for downlink and special subframes which are {12, 8, 7, 11} subframes (subframes k_m) earlier than uplink subframe 2 (i.e., downlink and special subframes {0, 4, 5, 1} (or downlink and special subframes $n-k_m$)) and M equals 4. Uplink subframe 3 (subframe n) handles ACK/NACK feedback for downlink subframes which are {6, 5, 4, 7} subframes (subframes k_m) earlier than uplink subframe 3 (i.e., downlink subframes {7, 8, 9, 6} (or downlink subframes $n-k_m$)) and M equals 4. For uplink-downlink configuration 5 uplink subframe 2, M equals 9. For uplink-downlink configuration 0, uplink subframe 2, M equals one, and uplink subframe 3, M equals zero. Depending on the uplink-downlink configuration one uplink subframe may be responsible for ACK/NACK feedback for one or multiple downlink subframes. In certain situations, even distribution between uplink subframe responsibility can be desired to reduce situations where one uplink subframe is responsible for ACK/NACK feedback for a large number of downlink and special subframes.

HARQ-ACK timing relation for UL-DL configuration 4 for uplink subframe 3, while correspondingly, the PCell may not have a HARQ-ACK timing defined (e.g., HARQ-ACK bundling window Mp=0) for configuration 0 for uplink subframe 3. In an example, HARQ-ACK bundling window may not be used for configuration 5, with 9 DL subframes.

An advantage of a Time Division Duplex (TDD) system can be a flexible resource utilization through different TDD configurations to better match the uplink and downlink traffic characteristics of the cell. By configuring different TDD configurations, the ratio between available UpLink (UL) and DownLink (DL) resources can range from 3UL:2DL (6UL:4DL) to 1 UL:9DL. In legacy LTE TDD (e.g., LTE Release 10 (Rel-10) specification), only the aggregation of TDD Component Carriers (CCs) of a same UL-DL configuration may be defined and supported. While the same UL-DL configuration can simplify a design and operation of CC, the same UL-DL configuration can also impose some limitations.

In an example, inter-band carrier aggregation (CA) for a TDD system with different uplink-downlink configurations on different bands can be supported. For instance, more than

one TDD carrier can be deployed by a single TDD operator and the carriers can be aggregated at a single base station (e.g., node). Besides, a separation between two carrier frequencies can be large enough to avoid UL-DL interference from a same device. Some of the benefits of inter-band CA with different TDD configurations on different bands can be include (1) legacy system co-existence, (2) heterogeneous network (HetNet) support, (3) aggregation of traffic-dependent carriers, (4) flexible configuration (e.g., more UL subframe in lower bands for better coverage, and more DL subframes in higher bands), and (5) higher peak rate.

Supporting Inter-band TDD Carrier Aggregation (CA) with different uplink-downlink configurations can be used to aggregate component carriers (CC) with different DL/UL configurations. To provide high peak data rate enhancement benefits to both full- and half-duplex UEs, HARQ (Hybrid Automatic Repeat reQuest) ACK/NACK feedback for downlink (DL) data may use a PUCCH only transmitted on Primary Cell (PCell), use legacy HARQ-ACK timing for PCell PDSCH by following a PCell SIB type 1 (SIB1) UL-DL configuration, and use HARQ-ACK timing for the PDSCH of a Secondary Cell (SCell) following a specific reference UL-DL configuration (e.g., PCell and SCell UL-DL configuration) as shown in Table 4 illustrated in FIG. **5**. For example, HARQ-ACK timing of the PDSCH on the PCell can follow the PCell SIB1 legacy UL/DL configuration. For the PDSCH transmitted on the SCell, the HARQ timing can follow reference legacy UL/DL configuration as shown in Table 4.

Interband TDD CA with different UL-DL configurations in different bands can be supported. For example, an SCell PDSCH HARQ reference timing can be determined from a PCell UL-DL configuration and a SCell UL-DL configuration, as shown in Table 4 illustrated in FIG. **5**. Table 4 (i.e., FIG. **5**) illustrates the UL-DL configuration number of PDSCH HARQ-ACK timing reference for SCell. A HARQ-ACK timing of PCell PDSCH, the scheduling timing of PCell PUSCH, the HARQ timing of PCell PUSCH can use the PCell SIB1 configuration. A UE can be configured with PUCCH format 3 or PUCCH format 1b with channel selection (CS) for HARQ-ACK transmission and self-carrier scheduling for TDD inter-band carrier aggregation (CA) with different UL-DL configurations on different bands.

A different number of downlink subframes can be bundled within an individual bundling window of each serving cell (e.g., PCell or SCell) as shown in FIG. **6**. According to the HARQ-ACK timing table (i.e., Table 4) for the SCell PDSCH, the size of HARQ-ACK bundling window can be different between PCell and SCell. FIG. **6** illustrates an example where the PCell is configured with TDD UL/DL configuration 0 and SCell is configured with TDD UL/DL configuration 4. Since the SCell can follow a different DL HARQ timing from the PCell, not only the bundling window of the SCell can be different from the PCell, but also the number of the HARQ-ACK bits (corresponding to the number of the DL subframes) in the SCell bundling window can be different from the PCell bundling window. As a result, legacy HARQ-ACK bit mapping and bundling rules may no longer applicable for a SCell UL-DL configuration with a different UL-DL configuration from the PCell or legacy HARQ-ACK bit mapping and bundling rules may no longer support a case with the SCell UL-DL configuration different from the PCell UL-DL configuration.

FIG. **6** illustrates varied HARQ-ACK bundling window sizes of the PCell and the SCell in case of inter-band TDD CA. An implication of different UL-DL configurations can be that different number of downlink subframes can be bundled within bundling window in each cell. For example, as shown in FIG. **6**, a PCell can use TDD configuration 0 and an SCell can use a TDD configuration 4. As illustrated, the size of bundling windows associated with the UL subframe 3 can be different for the two serving cells (e.g., PCell and SCell). For instance, a different number of downlink subframes can be bundled within individual bundling window of each serving cell. For example, a minimum value of bundling windows of two CCs can be zero. As shown in the example of in FIG. **6**, a value of bundling window size associated with uplink subframe 3 can be zero on the PCell, while a value of bundling window size can be 4 on the SCell (e.g., comprising subframe {6,7,8,9}) correspondingly under an assumption of a configuration 0 on the PCell and a configuration 4 on the SCell.

A UE can be configured with PUCCH format 3 or PUCCH format 1b with channel selection (CS) for HARQ-ACK transmission and self-carrier scheduling for TDD inter-band carrier aggregation (CA) with different UL-DL configurations on different bands. Various changes can be made to a legacy HARQ-ACK transmission configuration. For example, none of the PDSCH timing reference configurations of aggregated serving cells may be UL-DL configuration #5. The set of DL subframes (denoted as Kc) on serving cell c associated with UL subframe n can include the DL subframes n−k where k∈K and K is determined according to the TDD UL-DL configuration which the PDSCH HARQ timing on serving cell c follows. For HARQ-ACK transmission on PUCCH (at least for a case when Mp and Ms are positive), the UE can use legacy mapping table (e.g., Tables 5-12 illustrated in FIGS. **12-19**) with M=max{Mp, Ms}, where Mp is the number of elements in set Kc for the primary cell and Ms is the number of elements in set Kc for the secondary cell, or the UE can set a discontinuous transmission (DTX) for {HARQ-ACK(min{Mp, Ms}), . . . , HARQ-ACK(M−1)} for the serving cell with the smaller Mc value. Setting the DTX for {HARQ-ACK (min{Mp, Ms}), . . . , HARQ-ACK(M−1)} for the serving cell with the smaller Mc value is shown in Table 16 illustrated in FIG. **23** and shown and described in U.S. Provisional Patent Application Ser. No. 61/653,369, filed May 30, 2012; U.S. patent application Ser. No. 13/853,390 to Hong He, et al., entitled "HYBRID AUTOMATIC REPEAT REQUEST (HARQ) MAPPING FOR CARRIER AGGREGATION (CA)", filed Mar. 29, 2013, U.S. Provisional Patent Application Ser. No. 61/667,325, filed Jul. 2, 2012; and U.S. patent application Ser. No. 13/853,404 to Hong He, et al., entitled "HYBRID AUTOMATIC REPEAT REQUEST (HARQ) MAPPING FOR CARRIER AGGREGATION (CA)", filed Mar. 29, 2013, which is herein incorporated by reference in its entirety.

In another example, the UE can handle a case when any of a (Mp, Ms) is zero. The aforementioned solution to support PUCCH format 1b with CS can still be applicable even for the case of Min (Mp, Ms)=0. However, using methods for a min (Mp,Ms)>0 (i.e., Mp>0 and Ms>0) case (using Tables 11-12 (i.e., FIG. **18-19**)) instead of a method for min (Mp,Ms)=0 case can incur unnecessary time domain bundling when a number of ACK/NACK (NN) bits to be indicated after spatial bundling is greater than four (e.g., Ms=4 as shown in FIG. **6**). Therefore, technology (e.g., methods, devices, and computer circuitry) can be used for a case of Min (Mp, Ms)=0 to reduce a degradation of DL throughput performance over a case of Min (Mp, Ms)>0.

For example, for TDD HARQ-ACK multiplexing with PUCCH format 1b with channel selection and two configured serving cells, the UE can upon detection of a PDSCH

transmission or a PDCCH indicating downlink SPS release within subframe(s) n−k, where k∈K and K is determined according to the TDD UL-DL configuration which the PDSCH HARQ timing on serving cell c follows Table 3. As previously illustrated, Table 3 illustrates a downlink association set index K: $\{k_0, k_1, \ldots k_{M-1}\}$ for TDD.

The Mp can be a number of elements in a set K for the primary cell and the Ms can be a number of elements in the set K for the secondary cell, as shown in FIG. **7**. FIG. **7** illustrates various bundling window sizes of the PCell and the SCell for inter-band CA scenario.

A UE can conditionally determine a number of HARQ-ACK bits and corresponding PUCCH resource associated with PDSCH on SCell as provided by the description below.

For example, for TDD HARQ-ACK bundling or TDD HARQ-ACK multiplexing for one configured serving cell and a subframe n with Ms=1 and Mp=0, the UE can use PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ for transmission of HARQ-ACK in subframe n for p̃ mapped to antenna port p for PUCCH format 1a/1b, where if there is PDSCH transmission indicated by the detection of corresponding PDCCH (e.g., non-SPS configured subframe) or there is PDCCH indicating downlink SPS release within subframe(s) n−k on SCell, where k∈K and K is a set of M elements $\{k_0, k_1, \ldots k_{M-1}\}$ depending on the subframe n where M=Ms and the UL-DL configuration, the UE can first select a c value out of {0, 1, 2, 3} which makes $N_c \le n_{CCE} < N_{c+1}$ and can use a PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ by Expression 1 for antenna port p_0, where $N_{PUCCH}^{(1)}$ is configured by higher layers (e.g., RRC signaling), and n_{CCE} is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$ and the corresponding m, where $n-k_m$ is the smallest value in set K such that UE detects a PDCCH in subframe $n-k_m$.

$$n_{PUCCH,i}^{(1,\tilde{p}0)} = (M-m-1)\cdot N_c + m\cdot N_{c+1} + n_{CCE} + N_{PUCCH}^{(1)} \quad \text{[Expression 1]}$$

When a two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ for HARQ-ACK bundling for antenna port p_1 can be represented by Expression 2.

$$n_{PUCCH,i}^{(1,\tilde{p}0)} = (M-m-1)\cdot N_c + m\cdot N_{c+1} + n_{CCE} + 1 + N_{PUCCH}^{(1)} \quad \text{[Expression 2]}$$

For another example, for TDD HARQ-ACK multiplexing and sub-frame n with Ms >1 and Mp=0, the PUCCH resource can be denoted as $n_{PUCCH,i}^{(1)}$, which can be derived from a sub-frame $n-k_i$ on SCell, and an acknowledgement (ACK), Negative ACK (NACK), or discontinuous transmission (DTX) response (i.e., ACK/NACK/DTX response) can be denoted as HARQ-ACK(i) from the sub-frame $n-k_i$ on SCell, where $k_i \in K$ and $0 \le i \le M_S - 1$.

For a PDSCH transmission indicated by the detection of corresponding PDCCH (e.g., non-SPS configured subframe) or a PDCCH indicating downlink SPS release in sub-frame $n-k_i$ on SCell, where $k_i \in K$, the PUCCH resource $n_{PUCCH,i}^{(1)}$ can be represented by Expression 3, where c is selected from {0, 1, 2, 3} such that $N_c \le n_{CCE} < N_{c+1}$, $N_c = \max\{0, \lfloor [N_{RB}^{DL} \cdot (N_{sc}^{RB} \cdot c - 4)]/36 \rfloor\}$, $n_{CCE,i}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_i$, and $N_{PUCCH}^{(1)}$ is configured by higher layers.

$$n_{PUCCH,i}^{(1)} = (M-i-1)\cdot N_c + i\cdot N_{c+1} + n_{CCE,i} + N_{PUCCH}^{(1)} \quad \text{[Expression 3]}$$

For a PDSCH transmission where there is not a corresponding PDCCH detected in subframe $n-k_i$ on SCell (e.g., SPS configured subframe), the value of $n_{PUCCH,i}^{(1)}$ indicated by a ACK/negative ACK (NACK) resource indicator (ARI) for the PDSCH transmission can be determined according to higher layer configuration and 3GPP LTE standard Release 11 TS 36.213 Table 9.2-2 (e.g., Table 17 illustrated in FIG. **24**), where the ARI re-interprets a transmit power control (TPC) field in a downlink control information (DCI) format of the corresponding PDCCH.

Based on higher layer signaling, a UE with M can perform channel selection according to a set of LTE TS 36.213 Table 10.1.3-5 (e.g., Table 8), LTE TS 36.213 Table 10.1.3-6 (e.g., Table 9), and LTE TS 36.213 Table 10.1.3-7 (e.g., Table 10). In another example, based on higher layer signaling, a UE with M can perform channel selection according to a set of LTE TS 36.213 Table 10.1.3-2 (e.g., Table 5), LTE TS 36.213 Table 10.1.3-3 (e.g., Table 6), and LTE TS 36.213 Table 10.1.3-4 (e.g., Table 7). For a selected table set indicated by higher layer signaling, the UE can transmit b(0),b(1) (e.g., constellation bits) on PUCCH resource $n_{PUCCH}^{(1)}$ in sub-frame n using PUCCH format 1b according to 3GPP LTE standard Release 11 TS 36.211 section 5.4.1. The value of b(0),b(1) and the PUCCH resource $n_{PUCCH}^{(1)}$ can be generated by channel selection according to the selected set of Tables for Ms=2, 3, and 4 (e.g., Tables 8-10).

FIG. **20** (i.e., Table 13) illustrates a transmission of HARQ-ACK multiplexing for M=4 for a case of Min (Mp, Ms)>0. FIG. **21** (i.e., Table 14) illustrates a transmission of HARQ-ACK multiplexing for M=3 for a case of Min (Mp, Ms)>0. FIG. **22** (i.e., Table 15) illustrates a HARQ-ACK mapping table for PUCCH format 1b with channel selection (CS) for a case of Min (Mp, Ms)>0 for primary component carrier (PCC) and secondary component carrier (SCC) including constellation bits (e.g., b**0**, b**1**, b**2**, and b**3**) values (e.g., A for ACK, N for NACK, D for discontinuous transmission (DTX), and D/N for DTX/NACK) and PUCCH ACK/NACK (A/N) resources (e.g., h #) for reference signals (RS) and data with data constants (const.) using 1-4 bits (e.g., M=1, M=2, M=3, or M=4) representing a HARQ-ACK bundling window.

Another example provides a method **500** for hybrid automatic retransmission re-quest (HARQ) bundling used in carrier aggregation (CA) at a user equipment (UE), as shown in the flow chart in FIG. **8**. The method may be executed as instructions on a machine, computer circuitry, or a processor for the UE, where the instructions are included on at least one computer readable medium or one non-transitory machine readable storage medium. The method includes the operation of receiving, at the UE, an uplink-downlink (UL-DL) configuration for a primary cell (PCell) and an UL-DL configuration for a secondary cell (SCell), as in block **510**. The operation of determining a secondary HARQ bundling window size for a subframe based on the UL-DL configuration for the SCell and a primary HARQ bundling window size for the subframe based on the UL-DL configuration for the PCell follows, as in block **520**. The next operation of the method can be determining a physical uplink control channel (PUCCH) resource $n_{PUCCH}^{(1)}$ for transmission of a HARQ-ACKnowledge (ACK) using the secondary HARQ bundling window size, as in block **530**. The operation of generating a HARQ-ACK for a physical downlink shared channel (PDSCH) of the SCell follows, as in block **540**. The method can further include transmitting the HARQ-ACK in the PUCCH) resource $n_{PUCCH}^{(1)}$, as in block **550**.

In an example, the PUCCH resource $n_{PUCCH}^{(1)}$ for transmission of the HARQ-ACK in a subframe n for a p̃ mapped to an antenna port p for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 PUCCH format 1a or 1b, can be represented by:

$n_{PUCCH,i}^{(1,\square p_0)}=(M-m-1)\cdot N_c+m\cdot N_{c+1}+n_{CCE}+N_{PUCCH}^{(1)}$ for antenna port p_0 for time division duplex (TDD) when the secondary HARQ bundling window size Ms=1 and the primary HARQ bundling window size Mp=0, where a HARQ bundling window size M=Ms, n_{CCE} is a first CCE index number used for transmission of a corresponding physical downlink control channel (PDCCH) in subframe $n-k_m$ and the corresponding m, where k_m is the smallest value in set K such that UE detects a PDCCH in subframe $n-k_m$,

$N_c=\max\{0,\lfloor[N_{RB}^{DL}\cdot(N_{sc}^{RB}\cdot c-4)]/36\rfloor\}$ where c is a value out of {0, 1, 2, 3} such that $N_c\le n_{CCE}<N_{c+1}$, N_{RB}^{DL} is a downlink bandwidth configuration, expressed in units of N_{sc}^{RB}, N_{sc}^{RB} is a resource block size in the frequency domain, expressed as a number of subcarriers, and $N_{PUCCH}^{(1)}$ is a starting PUCCH channel index for a PUCCH region in an uplink subframe and is configured by high layers (e.g., RRC signaling) for each UE; and

$n_{PUCCH,i}^{(1,\square p_1)}=(M-m-1)\cdot N_c+m\cdot N_{c+1}+n_{CCE}+1+N_{PUCCH}^{(1)}$ for antenna port p_1 for time division duplex (TDD) when the secondary HARQ bundling window size Ms=1 and primary HARQ bundling window size Mp=0 and a two port transmission is configured.

In another example, the PUCCH resource $n_{PUCCH}^{(1)}$ for transmission of the HARQ-ACK in a subframe n for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 PUCCH format 1a or 1b, can be represented by: $n_{PUCCH,i}^{(1)}=(M-i-1)\cdot N_c+i\cdot N_{c+1}+n_{CCE,i}+N_{PUCCH}^{(1)}$ for time division duplex (TDD) when the secondary HARQ bundling window size Ms >1 and the primary HARQ bundling window size Mp=0 for a physical downlink shared channel (PDSCH) transmission indicated by a detection of a corresponding physical downlink control channel (PDCCH) or a PDCCH indicating downlink semi-persistent scheduling (SPS) release in sub-frame $n-k_i$ on the SCell, where a HARQ bundling window size M=Ms, $n_{CCE,i}$ is a first CCE index number used for transmission of the corresponding physical downlink control channel (PDCCH) in subframe $n-k_i$ on the SCell, where $k_i\in K$ and K is a set of M elements $\{k_0, k_1, \ldots k_{M-1}\}$ and $0\le i\le M_s-1$,

$N_c=\max\{0,\lfloor[N_{RB}^{DL}\cdot(N_{sc}^{RB}\cdot c-4)]/36\rfloor\}$ where c is a value out of {0, 1, 2, 3} such that $N_c\le n_{CCE}<N_{c+1}$, N_{RB}^{DL} is a downlink bandwidth configuration, expressed in units of N_{sc}^{RB}, N_{sc}^{RB} is a resource block size in the frequency domain, expressed as a number of subcarriers, and $N_{PUCCH}^{(1)}$ is a starting PUCCH channel index for a PUCCH region in an uplink subframe and is configured by high layers for each UE; and $n_{PUCCH,i}^{(1)}$ where the value for $n_{PUCCH,i}^{(1)}$ is determined according to higher layer signaling and a table for PUCCH resource value for downlink SPS when the secondary HARQ bundling window size Ms >1 and the primary HARQ bundling window size Mp=0 for the PDSCH transmission where there is not a corresponding PDCCH in subframe $n-k_i$ on the SCell.

In another configuration when the secondary HARQ bundling window size Ms >1 and the primary HARQ bundling window size Mp=0, the method can further include channel selecting based on a HARQ bundling window size M=Ms, where Ms is the secondary HARQ bundling window size, using: A Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 Technical Specification (TS) 36.213 Table 10.1.3-5 (e.g., Table 8 illustrated in FIG. **15**) when Ms=2; a LTE TS 36.213 Table 10.1.3-6 (e.g., Table 9 illustrated in FIG. **16**) when Ms=3; or a LTE TS 36.213 Table 10.1.3-7 (e.g., Table 10 illustrated in FIG. **17**) when Ms=4. The method can further include determining a value of constellation bits b(0) and b(1) and the PUCCH resource $n_{PUCCH}^{(1)}$ based on the HARQ-ACK using tables for Ms equal to 2, 3, or 4. In another example, the UL-DL configuration for the PCell can be included in a system information block 1 (SIB1) transmitted on the PCell and the UL-DL configuration for the SCell can be included in a SIB1 transmitted on the SCell.

Another example provides functionality **600** of computer circuitry of a processor on a user equipment (UE) operable to dynamically alter hybrid automatic retransmission request (HARQ) mapping for carrier aggregation (CA), as shown in the flow chart in FIG. **9**. The functionality may be implemented as a method or the functionality may be executed as instructions on a machine, where the instructions are included on at least one computer readable medium or one non-transitory machine readable storage medium. The computer circuitry can be configured to determine a secondary HARQ bundling window size for a secondary cell (SCell), when a primary HARQ bundling window size for a primary cell (PCell) is zero, as in block **610**. The computer circuitry can be further configured to determine a physical uplink control channel (PUCCH) resource for transmission of a HARQ-ACKnowledge (ACK) feedback using the secondary HARQ bundling window size, as in block **620**. The computer circuitry can also be configured to transmit the HARQ-ACK feedback in the PUCCH resource, as in block **630**.

In an example, the PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ for transmission of the HARQ-ACK in a subframe n for a $\tilde{p}$ mapped to an antenna port p for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 PUCCH format 1a or 1b, can be represented by:

$n_{PUCCH,i}^{(1,\square p_0)}=(M-m-1)\cdot N_c+m\cdot N_{c+1}+n_{CCE}+N_{PUCCH}^{(1)}$ for antenna port p_0 for time division duplex (TDD) when the secondary HARQ bundling window size Ms=1 and the primary HARQ bundling window size Mp=0, where a HARQ bundling window size M=Ms, n_{CCE} is a first CCE index number used for transmission of a corresponding physical downlink control channel (PDCCH) in subframe $n-k_m$ and the corresponding m, where k_m is the smallest value in set K such that UE detects a PDCCH in subframe $n-k_m$,

$N_c=\max\{0,\lfloor[N_{RB}^{DL}\cdot(N_{sc}^{RB}\cdot c-4)]/36\rfloor\}$ where c is a value out of {0, 1, 2, 3} such that $N_c\le n_{CCE}<N_{c+1}$, N_{RB}^{DL} is a downlink bandwidth configuration, expressed in units of N_{sc}^{RB}, N_{sc}^{RB}, is a resource block size in the frequency domain, expressed as a number of subcarriers, and $n_{PUCCH}^{(1)}$ is a starting PUCCH channel index for a PUCCH region in an uplink subframe and is configured by high layers (e.g., RRC signaling) for each UE; and

$n_{PUCCH,i}^{(1,\square p_1)}=(M-m-1)\cdot N_c+m\cdot N_{c+1}+n_{CCE}+1+N_{PUCCH}^{(1)}$ for antenna port p_1 for time division duplex (TDD) when the secondary HARQ bundling window size Ms=1 and primary HARQ bundling window size Mp=0 and a two port transmission is configured.

In another example, the PUCCH resource $n_{PUCCH}^{(1)}$ for transmission of the HARQ-ACK in a subframe n for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 PUCCH format 1a or 1b, can be represented by: $n_{PUCCH,i}^{(1)}=(M-i-1)\cdot N_c+i\cdot N_{c+1}+n_{CCE,i}+N_{PUCCH}^{(1)}$ for time division duplex (TDD) when the secondary HARQ bundling window size Ms >1 and the primary HARQ bundling window size Mp=0 for a physical downlink shared channel (PDSCH) transmission indicated by a detection of a corresponding physical downlink control channel (PDCCH) or a PDCCH indicating downlink semi-persistent scheduling (SPS) release in sub-frame $n-k_i$ on the SCell,

where a HARQ bundling window size M=Ms, $n_{CCE,i}$ is a first CCE index number used for transmission of the corresponding physical downlink control channel (PDCCH) in subframe $n-k_i$ on the SCell, where $k_i \epsilon K$ and K is a set of M elements $\{k_0, k_1, \ldots k_{M-1}\}$ and $0 \le i \le M_s-1$, $N_c=\max\{0,\lfloor[N_{RB}^{DL}\cdot(N_{sc}^{RB}\cdot c-4)]/36\rfloor\}$ where c is a value out of {0, 1, 2, 3} such that $N_c \le n_{CCE} < N_{c+1}$, N_{RB}^{DL} is a downlink bandwidth configuration, expressed in units of N_{sc}^{RB}, N_{sc}^{RB} is a resource block size in the frequency domain, expressed as a number of subcarriers, and $n_{PUCCH}^{(1)}$ is a starting PUCCH channel index for a PUCCH region in an uplink subframe and is configured by high layers for each UE; and $n_{PUCCH,i}^{(1)}$ where the value for $n_{PUCCH,i}^{(1)}$ is determined according to higher layer signaling and a table for PUCCH resource value for downlink SPS when the secondary HARQ bundling window size Ms >1 and the primary HARQ bundling window size Mp=0 for the PDSCH transmission where there is not a corresponding PDCCH in subframe $n-k_i$ on the SCell.

In another configuration, the computer circuitry can be further configured to perform channel selection based on a HARQ bundling window size M=Ms, where Ms is the secondary HARQ bundling window size, where: The computer circuitry uses a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 Technical Specification (TS) 36.213 Table 10.1.3-5 (e.g., Table 8 illustrated in FIG. **15**) when Ms=2; the computer circuitry uses a LTE TS 36.213 Table 10.1.3-6 (e.g., Table 9 illustrated in FIG. **16**) when Ms=3; or the computer circuitry uses a LTE TS 36.213 Table 10.1.3-7 (e.g., Table 10 illustrated in FIG. **17**) when Ms=4. The computer circuitry configured to transmit the HARQ-ACK feedback can be further configured to determine a value of constellation bits b(0) and b(1) and the PUCCH resource $n_{PUCCH}^{(1)}$ based on the HARQ-ACK feedback using tables for Ms equal to 2, 3, or 4.

FIG. **10** illustrates an example node (e.g., serving node **710** and cooperation node **750**) and an example wireless device **720**. The node can include a node device **712** and **752**. The node device or the node can be configured to communicate with the wireless device. The node device, device at the node, or the node can be configured to communicate with other nodes via a backhaul link **748** (optical or wired link), such as an X2 application protocol (X2AP). The node device can include a processor **714** and **754** and a transceiver **716** and **756**. The transceiver can be configured to receive a HARQ-ACK feedback in a PUCCH resource. The transceiver **716** and **756** can be further configured to communicate with the coordination node via an X2 application protocol (X2AP). The processor can be further configured to a reverse procedure can be implemented for PUCCH detection and PDSCH retransmission as disclosed herein. The serving node can generate both the PCell and the SCell. The node (e.g., serving node **710** and cooperation node **750**) can include a base station (BS), a Node B (NB), an evolved Node B (eNB), a baseband unit (BBU), a remote radio head (RRH), a remote radio equipment (RRE), a remote radio unit (RRU), or a central processing module (CPM).

The device (used by a node) can be configured to detect a hybrid automatic retransmission re-quest (HARQ) bundle used in carrier aggregation (CA). The transceiver **716** and **756** can be configured to receive constellation bits in a physical uplink control channel (PUCCH) resource in a subframe transmitted in a primary cell (PCell) for a physical downlink shared channel (PDSCH) of a secondary cell (SCell). The processor **714** and **754** can be configured to:

Determine a secondary HARQ bundling window size for a subframe based on an uplink-downlink (UL-DL) configuration for the SCell and a primary HARQ bundling window size for the subframe based on an UL-DL configuration for the PCell; and determine a HARQ-ACKnowledge (ACK) response for the subframe for the SCell using the secondary HARQ bundling window size and the PUCCH resource, when the primary HARQ bundling window size is zero.

In an example, the PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ for transmission of the HARQ-ACK in a subframe n for a $\tilde{p}$ mapped to an antenna port p for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 PUCCH format 1a or 1b, can be represented by: $n_{PUCCH,i}^{(1,p_0)}=(M-m-1)\cdot N_c+m\cdot N_{c+1}+n_{CCE}+N_{PUCCH}^{(1)}$ for antenna port p_0 for time division duplex (TDD) when the secondary HARQ bundling window size Ms=1 and the primary HARQ bundling window size Mp=0, where a HARQ bundling window size M=Ms, n_{CCE} is a first CCE index number used for transmission of a corresponding physical downlink control channel (PDCCH) in subframe $n-k_m$ and the corresponding m, where k_m is the smallest value in set K such that UE detects a PDCCH in subframe $n-k_m$, $N_c=\max\{0,\lfloor[N_{RB}^{DL}\cdot(N_{sc}^{RB}\cdot c-4)]/36\rfloor\}$ where c is a value out of {0, 1, 2, 3} such that $N_c \le n_{CCE} < N_{c+1}$, N_{RB}^{DL} is a downlink bandwidth configuration, expressed in units of N_{sc}^{RB}, N_{sc}^{RB}, is a resource block size in the frequency domain, expressed as a number of subcarriers, and $N_{PUCCH}^{(1)}$ is a starting PUCCH channel index for a PUCCH region in an uplink subframe and is configured by high layers for each UE; and $n_{PUCCH,i}^{(1,p_1)}=(M-m-1)\cdot N_c+m\cdot N_{c+1}+n_{CCE}+1+N_{PUCCH}^{(1)}$ for antenna port p_1 for time division duplex (TDD) when the secondary HARQ bundling window size Ms=1 and primary HARQ bundling window size Mp=0 and a two port transmission is configured.

In another example, the PUCCH resource $n_{PUCCH}^{(1)}$ for transmission of the HARQ-ACK in a subframe n for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 PUCCH format 1a or 1b, can be represented by: $n_{PUCCH,i}^{(1)}=(M-i-1)\cdot N_c+i\cdot N_{c+1}+n_{CCE,i}+n_{PUCCH}^{(1)}$ for time division duplex (TDD) when the secondary HARQ bundling window size Ms >1 and the primary HARQ bundling window size Mp=0 for a physical downlink shared channel (PDSCH) transmission indicated by a detection of a corresponding physical downlink control channel (PDCCH) or a PDCCH indicating downlink semi-persistent scheduling (SPS) release in sub-frame $n-k_i$ on the SCell, where a HARQ bundling window size M=Ms, $n_{CCE,i}$ is a first CCE index number used for transmission of the corresponding physical downlink control channel (PDCCH) in subframe $n-k_i$ on the SCell, where $k_i \epsilon K$ and K is a set of M elements $\{k_0, k_1, \ldots k_{M-1}\}$ and $0 \le i \le M_s-1$, $N_c=\max\{0,\lfloor[N_{RB}^{DL}\cdot(N_{sc}^{RB}\cdot c-4)]/36\rfloor\}$ where c is a value out of {0, 1, 2, 3} such that $N_c \le n_{CCE} < N_{c+1}$, N is a downlink bandwidth configuration, expressed in units of N_{sc}^{RB}, N_{sc}^{RB} is a resource block size in the frequency domain, expressed as a number of subcarriers, and $n_{PUCCH}^{(1)}$ is a starting PUCCH channel index for a PUCCH region in an uplink subframe and is configured by high layers for each UE; and $n_{PUCCH,i}^{(1)}$ where the value for $n_{PUCCH,i}^{(1)}$ is determined according to higher layer signaling and a table for PUCCH resource value for downlink SPS when the secondary HARQ bundling window size Ms >1 and the primary HARQ

bundling window size Mp=0 for the PDSCH transmission where there is not a corresponding PDCCH in subframe $n-k_i$ on the SCell.

In another configuration, the HARQ-ACK response can be represented as HARQ-ACK(i) and can include a combination of ACK, negative ACK (NACK), or discontinuous transmission (DTX) responses from sub-frame $n-k_i$ on the SCell, where $k_i \epsilon K$ and K is a set of M elements $\{k_0, k_1, \ldots k_{M-1}\}$ and $0 \le i \le M_s - 1$. The higher layer signaling can include radio resource control (RRC) signaling.

In another example, the processor can be further configured to determine the HARQ-ACK response for the subframe for the SCell by applying the values of the constellation bits and the PUCCH resource to a HARQ-ACK multiplexing look-up table based on a HARQ bundling window size M=Ms, where Ms is the secondary HARQ bundling window size. The HARQ-ACK multiplexing look-up table can include a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 Technical Specification (TS) 36.213 Table 10.1.3-5 (e.g., Table 8 illustrated in FIG. **15**) when Ms=2; a LTE TS 36.213 Table 10.1.3-6 (e.g., Table 9 illustrated in FIG. **16**) when Ms=3; or a LTE TS 36.213 Table 10.1.3-7 (e.g., Table 10 illustrated in FIG. **17**) when Ms=4.

The wireless device **720** (e.g., UE) can include a transceiver **724** and a processor **722**. The wireless device (i.e., device) can be configured for conditional hybrid automatic retransmission re-quest (HARQ) mapping for carrier aggregation (CA), as described in **500** of FIG. **8** or **600** of FIG. **9**.

FIG. **11** provides an example illustration of the wireless device, such as an user equipment (UE), a mobile station (MS), a mobile wireless device, a mobile communication device, a tablet, a handset, or other type of wireless device. The wireless device can include one or more antennas configured to communicate with a node, macro node, low power node (LPN), or, transmission station, such as a base station (BS), an evolved Node B (eNB), a baseband unit (BBU), a remote radio head (RRH), a remote radio equipment (RRE), a relay station (RS), a radio equipment (RE), or other type of wireless wide area network (WWAN) access point. The wireless device can be configured to communicate using at least one wireless communication standard including 3GPP LTE, WiMAX, High Speed Packet Access (HSPA), Bluetooth, and WiFi. The wireless device can communicate using separate antennas for each wireless communication standard or shared antennas for multiple wireless communication standards. The wireless device can communicate in a wireless local area network (WLAN), a wireless personal area network (WPAN), and/or a WWAN.

FIG. **11** also provides an illustration of a microphone and one or more speakers that can be used for audio input and output from the wireless device. The display screen may be a liquid crystal display (LCD) screen, or other type of display screen such as an organic light emitting diode (OLED) display. The display screen can be configured as a touch screen. The touch screen may use capacitive, resistive, or another type of touch screen technology. An application processor and a graphics processor can be coupled to internal memory to provide processing and display capabilities. A non-volatile memory port can also be used to provide data input/output options to a user. The non-volatile memory port may also be used to expand the memory capabilities of the wireless device. A keyboard may be integrated with the wireless device or wirelessly connected to the wireless device to provide additional user input. A virtual keyboard may also be provided using the touch screen.

Various techniques, or certain aspects or portions thereof, may take the form of program code (i.e., instructions) embodied in tangible media, such as floppy diskettes, CD-ROMs, hard drives, non-transitory computer readable storage medium, or any other machine-readable storage medium wherein, when the program code is loaded into and executed by a machine, such as a computer, the machine becomes an apparatus for practicing the various techniques. Circuitry can include hardware, firmware, program code, executable code, computer instructions, and/or software. A non-transitory computer readable storage medium can be a computer readable storage medium that does not include signal. In the case of program code execution on programmable computers, the computing device may include a processor, a storage medium readable by the processor (including volatile and non-volatile memory and/or storage elements), at least one input device, and at least one output device. The volatile and non-volatile memory and/or storage elements may be a RAM, EPROM, flash drive, optical drive, magnetic hard drive, solid state drive, or other medium for storing electronic data. The node and wireless device may also include a transceiver module, a counter module, a processing module, and/or a clock module or timer module. One or more programs that may implement or utilize the various techniques described herein may use an application programming interface (API), reusable controls, and the like. Such programs may be implemented in a high level procedural or object oriented programming language to communicate with a computer system. However, the program(s) may be implemented in assembly or machine language, if desired. In any case, the language may be a compiled or interpreted language, and combined with hardware implementations.

It should be understood that many of the functional units described in this specification have been labeled as modules, in order to more particularly emphasize their implementation independence. For example, a module may be implemented as a hardware circuit comprising custom VLSI circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices or the like.

Modules may also be implemented in software for execution by various types of processors or logic. An identified module of executable code may, for instance, comprise one or more physical or logical blocks of computer instructions, which may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module need not be physically located together, but may comprise disparate instructions stored in different locations which, when joined logically together, comprise the module and achieve the stated purpose for the module.

Indeed, a module of executable code may be a single instruction, or many instructions, and may even be distributed over several different code segments, among different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within modules, and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different storage devices, and may exist, at least partially, merely as electronic signals on a system or network. The modules may be passive or active, including agents operable to perform desired functions.

Reference throughout this specification to "an example" means that a particular feature, structure, or characteristic described in connection with the example is included in at least one embodiment of the present invention. Thus, appearances of the phrases "in an example" in various places throughout this specification are not necessarily all referring to the same embodiment.

As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary. In addition, various embodiments and example of the present invention may be referred to herein along with alternatives for the various components thereof. It is understood that such embodiments, examples, and alternatives are not to be construed as defacto equivalents of one another, but are to be considered as separate and autonomous representations of the present invention.

Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the following description, numerous specific details are provided, such as examples of layouts, distances, network examples, etc., to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, layouts, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the invention.

While the forgoing examples are illustrative of the principles of the present invention in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without the exercise of inventive faculty, and without departing from the principles and concepts of the invention. Accordingly, it is not intended that the invention be limited, except as by the claims set forth below.

What is claimed is:

1. A user equipment (UE) operable to dynamically alter hybrid automatic retransmission re-quest (HARQ) mapping for carrier aggregation (CA), having computer circuitry configured to:

determine a secondary HARQ bundling window size for a subframe for a secondary cell (SCell) based on uplink-downlink (UL-DL) configuration of the SCell, wherein the secondary HARQ bundling window includes at least one of a number of downlink (DL) subframes or a previous radio frame, when a primary HARQ bundling window size for a primary cell (PCell) is zero;

determine a physical uplink control channel (PUCCH) resource for transmission of a HARQ-ACKnowledge (ACK) feedback for a physical downlink shared channel (PDSCH) on the PCell and the SCell based on a number of a first Control Channel Element (CCE) used to construct a physical downlink control channel (PDCCH) for transmission of a corresponding PDSCH in the secondary HARQ bundling window of the SCell; and

transmit the HARQ-ACK feedback in the determined PUCCH resource, wherein the PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ for transmission of the HARQ-ACK in a subframe n for a $\tilde{p}$ mapped to an antenna port p for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 PUCCH format 1a or 1b, is represented by:

$n_{PUCCH,i}^{(1,\tilde{p}_0)}=(M-m-1)\cdot N_c+m\cdot N_{c+1}+n_{CCE}+N_{PUCCH}^{(1)}$ for antenna port p_0 for time division duplex (TDD) when the secondary HARQ bundling window size Ms=1 and the primary HARQ bundling window size Mp=0, where a HARQ bundling window size M=Ms, n_{CCE} is a number of a first CCE index used for transmission of a corresponding physical downlink control channel (PDCCH) in subframe $n-k_m$ and the corresponding m, where k_m is the smallest value in set K such that UE detects a PDCCH in subframe $n-k_m$,

$N_c=\max\{0,\lfloor[N_{RB}^{DL}\cdot(N_{sc}^{RB}\cdot c-4)]/36\rfloor\}$ where c is a value out of {0, 1, 2, 3} such that $N_c\le n_{CCE}<N_{c+1}$, N_{RB}^{DL} is a downlink bandwidth configuration, expressed in units of N_{sc}^{RB}, N_{sc}^{RB} is a resource block size in the frequency domain, expressed as a number of subcarriers, and $N_{PUCCH}^{(1)}$ is a starting PUCCH channel index for a PUCCH region in an uplink subframe and is configured by high layers for each UE; and

$n_{PUCCH,i}^{(1,\tilde{p}_1)}=(M-m-1)\cdot N_c+m\cdot N_{c+1}+n_{CCE}+1+N_{PUCCH}^{(1)}$ for antenna port p_1 for time division duplex (TDD) when the secondary HARQ bundling window size Ms=1 and primary HARQ bundling window size Mp=0 and a two port transmission is configured.

2. The computer circuitry of claim **1**, wherein:

the PUCCH resource $n_{PUCCH}^{(1)}$ for transmission of the HARQ-ACK in a subframe n for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 PUCCH format 1a or 1b, is represented by:

$n_{PUCCH,i}^{(1)}=(M-i-1)\cdot N_c+i\cdot N_{c+1}+N_{CCE,i}+N_{PUCCH}^{(1)}$ for time division duplex (TDD) when the secondary HARQ bundling window size Ms>1 and the primary HARQ bundling window size Mp=0 for a physical downlink shared channel (PDSCH) transmission indicated by a detection of a corresponding physical downlink control channel (PDCCH) or a PDCCH indicating downlink semi-persistent scheduling (SPS) release in sub-frame $n-k_i$ on the SCell, where a HARQ bundling window size M=Ms, $n_{CCE,i}$ is a first CCE index number used for transmission of the corresponding physical downlink control channel (PDCCH) in subframe $n-k_i$ on the SCell, where $k_i\in K$ and K is a set of M elements $\{k_0, k_1, \ldots k_{M-1}\}$ and $0\le i\le M_s-1$,

$N_c=\max\{0,\lfloor[N_{RB}^{DL}\cdot(N_{sc}^{RB}\cdot c-4)]/36\rfloor\}$ where c is a value out of {0, 1, 2, 3} such that $N_c\le n_{CCE}<N_{c+1}$, N_{RB}^{DL} is a downlink bandwidth configuration, expressed in units of N_{sc}^{RB}, N_{sc}^{RB} is a resource block size in the frequency domain, expressed as a number of subcarriers, and $N_{PUCCH}^{(1)}$ is a starting PUCCH channel index for a PUCCH region in an uplink subframe and is configured by high layers for each UE; and

$n_{PUCCH,i}^{(1)}$ where the value for $n_{PUCCH,i}^{(1)}$ is determined according to higher layer signaling and a table for PUCCH resource value for downlink SPS when the secondary HARQ bundling window size Ms>1 and the primary HARQ bundling window size Mp=0

for the PDSCH transmission where there is not a corresponding PDCCH in subframe $n-k_i$ on the SCell.

3. The computer circuitry of claim 2, wherein the HARQ-ACK feedback is represented as HARQ-ACK(i) and includes a combination of ACK, negative ACK (NACK), or discontinuous transmission (DTX) responses from subframe $n-k_i$ on the SCell, where $k_i \epsilon K$ and K is a set of M elements $\{k_0, k_1, \ldots k_{M-1}\}$ and $0 \le i \le M_s-1$.

4. The computer circuitry of claim 1, further configured to:

perform channel selection based on a HARQ bundling window size M=Ms, where Ms is the secondary HARQ bundling window size, wherein:

the computer circuitry uses a Table 10.1.3-5 in a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 Technical Specification (TS) 36.213 when Ms=2;

the computer circuitry uses a Table 10.1.3-6 in the TS 36.213 when Ms=3; or

the computer circuitry uses a Table 10.1.3-7 in the TS 36.213 when Ms=4,

wherein the Table 10.1.3-5 in the TS 36.213 is:

HARQ-ACK(0), HARQ-ACK(1)	$n_{PUCCH}^{(1)}$	b(0)b(1)
ACK, ACK	$n_{PUCCH,1}^{(1)}$	1, 0
ACK, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 1
NACK/DTX, ACK	$n_{PUCCH,1}^{(1)}$	0, 1
NACK, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 0
DTX, NACK/DTX	No Transmission	

the Table 10.1.3-6 in the TS 36.213 is:

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	$n_{PUCCH}^{(1)}$	b(0)b(1)
ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	1, 1
ACK, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	1, 0
ACK, NACK/DTX, ACK	$n_{PUCCH,2}^{(1)}$	1, 0
ACK, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 1
NACK/DTX, ACK, ACK	$n_{PUCCH,2}^{(1)}$	0, 1
NACK/DTX, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK	$n_{PUCCH,2}^{(1)}$	0, 0
NACK, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 0
DTX, NACK/DTX, NACK/DTX	No Transmission	

the Table 10.1.3-7 in the TS 36.213 is:

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	$n_{PUCCH}^{(1)}$	b(0)b(1)
ACK, ACK, ACK, ACK	$n_{PUCCH,1}^{(1)}$	1, 1
ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	1, 1
ACK, ACK, NACK/DTX, ACK	$n_{PUCCH,0}^{(1)}$	1, 0
ACK, ACK, NACK/DTX, NACK/DTX	$n_{PUCCH,1}^{(1)}$	1, 0
ACK, NACK/DTX, ACK, ACK	$n_{PUCCH,3}^{(1)}$	1, 1
ACK, NACK/DTX, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	1, 0
ACK, NACK/DTX, NACK/DTX, ACK	$n_{PUCCH,0}^{(1)}$	0, 1
ACK, NACK/DTX, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 1
NACK/DTX, ACK, ACK, ACK	$n_{PUCCH,1}^{(1)}$	0, 0
NACK/DTX, ACK, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	0, 1
NACK/DTX, ACK, NACK/DTX, ACK	$n_{PUCCH,3}^{(1)}$	1, 0
NACK/DTX, ACK, NACK/DTX, NACK/DTX	$n_{PUCCH,1}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK, ACK	$n_{PUCCH,3}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	0, 0
NACK/DTX, NACK/DTX, NACK/DTX, ACK	$n_{PUCCH,3}^{(1)}$	0, 0
NACK, NACK/DTX, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 0
DTX, NACK/DTX, NACK/DTX, NACK/DTX	No Transmission.	

5. The computer circuitry of claim 4, wherein computer circuitry configured to transmit the HARQ-ACK feedback is further configured to:

determine a value of constellation bits b(0) and b(1) and the PUCCH resource $n_{PUCCH}^{(1)}$ based on the HARQ-ACK feedback using tables for Ms equal to 2, 3, or 4.

6. The computer circuitry of claim 1, wherein the UE includes an antenna, a touch sensitive display screen, a speaker, a microphone, a graphics processor, an application processor, internal memory, or a non-volatile memory port.

7. A method for hybrid automatic retransmission re-quest (HARQ) bundling used in carrier aggregation (CA) at a user equipment (UE), comprising:

receiving, at the UE, an uplink-downlink (UL-DL) configuration for a primary cell (PCell) and an UL-DL configuration for a secondary cell (SCell);

determining a secondary HARQ bundling window size for a subframe based on the UL-DL configuration for the SCell and a primary HARQ bundling window size for the subframe based on the UL-DL configuration for the PCell, wherein the secondary HARQ bundling window includes at least one of a number of downlink (DL) subframes or a previous radio frame;

determining a physical uplink control channel (PUCCH) resource $n_{PUCCH}^{(1)}$ for transmission of a HARQ-AC-Knowledge (ACK) for a physical downlink shared channel (PDSCH) on the PCell and the SCell based on a number of a first Control Channel Element (CCE) used to construct a physical downlink control channel (PDCCH) for transmission of a corresponding PDSCH using the secondary HARQ bundling window of the SCell;

generating a HARQ-ACK for a physical downlink shared channel (PDSCH) of the SCell; and

transmitting the HARQ-ACK in the determined PUCCH resource $n_{PUCCH}^{(1)}$, wherein the PUCCH resource $n_{PUCCH}^{(1)}$ for transmission of the HARQ-ACK in a subframe n for a $\tilde{p}$ mapped to an antenna port p for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 PUCCH format 1a or 1b, is represented by:

$n_{PUCCH,i}^{(1,\tilde{p}_0)}=(M-m-1)\cdot N_c+m\cdot N_{c+1}+n_{CCE}+N_{PUCCH}^{(1)}$ for antenna port p_0, for time division duplex (TDD) when the secondary HARQ bundling window size Ms=1 and the primary HARQ bundling window size Mp=0, where a HARQ bundling window size M=Ms, n_{CCE} is a number of a first CCE index used for transmission of a corresponding physical downlink control channel (PDCCH) in subframe $n-k_m$ and the corresponding m, where k_m is the smallest value in set K such that UE detects a PDCCH in subframe $n-k_m$,

$N_c=\max\{0,\lfloor[N_{RB}^{DL}\cdot(N_{sc}^{RB}\cdot c-4)]/36\rfloor\}$ where c is a value out of {0, 1, 2, 3} such that $N_c \le n_{CCE} < N_{c+1}$, N_{RB}^{DL} is a downlink bandwidth configuration, expressed in units of N_{sc}^{RB}, N_{sc}^{RB} is a resource block size in the frequency domain, expressed as a number of subcarriers, and $N_{PUCCH}^{(1)}$ is a starting PUCCH channel index for a PUCCH region in an uplink subframe and is configured by high layers for each UE; and

$n_{PUCCH,i}^{(1,\tilde{p}_1)}=(M-m-1)\cdot N_c+m\cdot N_{c+1}+n_{CCE}+1+N_{PUCCH}^{(1)}$ for antenna port p_1 for time division duplex (TDD) when the secondary HARQ bundling window size Ms=1 and primary HARQ bundling window size Mp=0 and a two port transmission is configured.

8. The method of claim 7, wherein:

the PUCCH resource $n_{PUCCH}^{(1)}$ for transmission of the HARQ-ACK in a subframe n for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 PUCCH format 1a or 1b, is represented by:

$n_{PUCCH,i}^{(1)}=(M-i-1)\cdot N_c+i\cdot N_{c+1}+n_{CCE,i}+N_{PUCCH}^{(1)}$ for time Division duplex (TDD) when the secondary HARQ bundling window size Ms>1 and the primary HARQ bundling window size Mp=0 for a physical downlink shared channel (PDSCH) transmission indicated by a detection of a corresponding physical downlink control channel (PDCCH) or a PDCCH indicating downlink semi-persistent scheduling (SPS) release in sub-frame $n-k_i$ on the SCell, where a HARQ bundling window size M=Ms, $n_{CCE,i}$ is a first CCE index number used for transmission of the corresponding physical downlink control channel (PDCCH) in subframe $n-k_i$ on the SCell, where $k_i \in K$ and K is a set of M elements $\{k_0, k_1, \ldots k_{M-1}\}$ and $0 \le i \le M_s-1$,

$N_c=\max\{0,\lfloor[N_{RB}^{DL}\cdot(N_{sc}^{RB}\cdot c-4)]/36\rfloor\}$ where c is a value out of {0, 1, 2, 3} such that $N_c \le n_{CCE} < N_{c+1}$, N_{RB}^{DL} is a downlink bandwidth configuration, expressed in units of N_{sc}^{RB}, N_{sc}^{RB} is a resource block size in the frequency domain, expressed as a number of subcarriers, and $N_{PUCCH}^{(1)}$ is a starting PUCCH channel index for a PUCCH region in an uplink subframe and is configured by high layers for each UE; and

$n_{PUCCH,i}^{(1)}$ where the value for $n_{PUCCH,i}^{(1)}$ is determined according to higher layer signaling and a table for PUCCH resource value for downlink SPS when the secondary HARQ bundling window size Ms>1 and the primary HARQ bundling window size Mp=0 for the PDSCH transmission where there is not a corresponding PDCCH in subframe $n-k_i$ on the SCell.

9. The method of claim 8, further comprising:

channel selecting based on a HARQ bundling window size M=Ms, where Ms is the secondary HARQ bundling window size, using:

a Table 10.1.3-5 in a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 Technical Specification (TS) 36.213 when Ms=2;

a Table 10.1.3-6 in the TS 36.213 when Ms=3; or

a Table 10.1.3-7 in the TS 36.213 when Ms=4,

perform channel selection based on a HARQ bundling window size M=Ms, where Ms is the secondary HARQ bundling window size, wherein:

the Table 10.1.3-5 in the TS 36.213 is:

HARQ-ACK(0), HARQ-ACK(1)	$n_{PUCCH}^{(1)}$	b(0)b(1)
ACK, ACK	$n_{PUCCH,1}^{(1)}$	1, 0
ACK, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 1
NACK/DTX, ACK	$n_{PUCCH,1}^{(1)}$	0, 1
NACK, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 0
DTX, NACK/DTX	No Transmission	

the Table 10.1.3-6 in the TS 36.213 is:

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	$n_{PUCCH}^{(1)}$	b(0)b(1)
ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	1, 1
ACK, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	1, 0
ACK, NACK/DTX, ACK	$n_{PUCCH,2}^{(1)}$	1, 0
ACK, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 1
NACK/DTX, ACK, ACK	$n_{PUCCH,2}^{(1)}$	0, 1
NACK/DTX, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK	$n_{PUCCH,2}^{(1)}$	0, 0
NACK, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 0
DTX, NACK/DTX, NACK/DTX	No Transmission	

the Table 10.1.3-7 in the TS 36.213 is:

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	$n_{PUCCH}^{(1)}$	b(0)b(1)
ACK, ACK, ACK, ACK	$n_{PUCCH,1}^{(1)}$	1, 1
ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	1, 1
ACK, ACK, NACK/DTX, ACK	$n_{PUCCH,0}^{(1)}$	1, 0
ACK, ACK, NACK/DTX, NACK/DTX	$n_{PUCCH,1}^{(1)}$	1, 0
ACK, NACK/DTX, ACK, ACK	$n_{PUCCH,3}^{(1)}$	1, 1
ACK, NACK/DTX, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	1, 0
ACK, NACK/DTX, NACK/DTX, ACK	$n_{PUCCH,0}^{(1)}$	0, 1
ACK, NACK/DTX, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 1
NACK/DTX, ACK, ACK, ACK	$n_{PUCCH,1}^{(1)}$	0, 0
NACK/DTX, ACK, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	0, 1
NACK/DTX, ACK, NACK/DTX, ACK	$n_{PUCCH,3}^{(1)}$	1, 0
NACK/DTX, ACK, NACK/DTX, NACK/DTX	$n_{PUCCH,1}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK, ACK	$n_{PUCCH,3}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	0, 0
NACK/DTX, NACK/DTX, NACK/DTX, ACK	$n_{PUCCH,3}^{(1)}$	0, 0
NACK, NACK/DTX, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 0
DTX, NACK/DTX, NACK/DTX, NACK/DTX	No Transmission.	

10. The method of claim 9, further comprising:

determining a value of constellation bits b(0) and b(1) and the PUCCH resource $n_{PUCCH}^{(1)}$ based on the HARQ-ACK using tables for Ms equal to 2, 3, or 4.

11. The method of claim 7, wherein the UL-DL configuration for the PCell is included in a system information block 1 (SIB1) transmitted on the PCell and the UL-DL configuration for the SCell is included in a SIB1 transmitted on the SCell.

12. At least one non-transitory machine readable storage medium comprising a plurality of instructions adapted to be executed to implement the method of claim 7.

13. A device at a node configured to detect a hybrid automatic retransmission re-quest (HARQ) bundle used in carrier aggregation (CA), comprising:

a transceiver to receive constellation bits in a physical uplink control channel (PUCCH) resource in a subframe transmitted in a primary cell (PCell) for a physical downlink shared channel (PDSCH) of a secondary cell (SCell), wherein the PUCCH resource is determined for transmission of a HARQ-ACKnowledge (ACK) response for a physical downlink shared channel (PDSCH) on the PCell and the SCell based on a number of a first Control Channel Element (CCE) used to construct a physical downlink control channel (PDCCH) for transmission of a corresponding PDSCH in a secondary HARQ bundling window of the SCell; and

a processor to:

determine the secondary HARQ bundling window size for a subframe based on an uplink-downlink (UL-DL) configuration for the SCell and a primary HARQ bundling window size for the subframe based on an UL-DL configuration for the PCell, wherein the secondary HARQ bundling window includes at

least one of a number of downlink (DL) subframes or a previous radio frame, and

determine a HARQ-ACKnowledge (ACK) response for the subframe for the SCell using the secondary HARQ bundling window size and the PUCCH resource, when the primary HARQ bundling window size is zero, wherein the PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ for transmission of the HARQ-ACK in a subframe n for a $\tilde{p}$ mapped to an antenna port p for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 PUCCH format 1a or 1b, is represented by:

$n_{PUCCH,i}^{(1,\tilde{p}_0)}=(M-m-1)\cdot N_c+m\cdot N_{c+1}+n_{CCE}+N_{PUCCH}^{(1)}$ for antenna port p_0, for time division duplex (TDD) when the secondary HARQ bundling window size Ms=1 and the primary HARQ bundling window size Mp=0, where a HARQ bundling window size M=Ms, n_{CCE} is a number of a first CCE index used for transmission of a corresponding physical downlink control channel (PDCCH) in subframe $n-k_m$ and the corresponding m, where k_m is the smallest value in set K such that UE detects a PDCCH in subframe $n-k_m$,

$N_c=\max\{0,\lfloor[N_{RB}^{DL}\cdot(N_{sc}^{RB}\cdot c-4)]/36\rfloor\}$ where c is a value out of {0, 1, 2, 3} such that $N_c\le n_{CCE}<N_{c+1}$, N_{RB}^{DL} is a downlink bandwidth configuration, expressed in units of N_{sc}^{RB}, N_{sc}^{RB} is a resource block size in the frequency domain, expressed as a number of subcarriers, and $N_{PUCCH}^{(1)}$ is a starting PUCCH channel index for a PUCCH region in an uplink subframe and is configured by high layers for each UE; and

$n_{PUCCH,i}^{(1,\tilde{p}_1)}=(M-m-1)\cdot N_c+m\cdot N_{c+1}+n_{CCE}+1+N_{PUCCH}^{(1)}$ for antenna oport p_1 for time division duplex (TDD) when the secondary HARQ bundling window size Ms=1 and primary HARQ bundling window size Mp=0 and a two port transmission is configured.

14. The device of claim **13**, wherein:

the PUCCH resource $n_{PUCCH}^{(1)}$ for transmission of the HARQ-ACK in a subframe n for a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 PUCCH format 1a or 1b, is represented by:

$n_{PUCCH,i}^{(1)}=(M-i-1)\cdot N_c+i\cdot N_{c+1}+n_{CCE,i}+N_{CCE,i}+N_{PUCCH}^{(1)}$ for time division duplex (TDD) when the secondary HARQ bundling window size Ms>1 and the primary HARQ bundling window size Mp=0 for a physical downlink shared channel (PDSCH) transmission indicated by a detection of a corresponding physical downlink control channel (PDCCH) or a PDCCH indicating downlink semi-persistent scheduling (SPS) release in sub-frame $n-k_i$ on the SCell, where a HARQ bundling window size M=Ms, $n_{CCE,i}$ is a first CCE index number used for transmission of the corresponding physical downlink control channel (PDCCH) in subframe $n-k_i$ on the SCell, where $k_i\in K$ and K is a set of M elements $\{k_0, k_1, \ldots k_{M-1}\}$ and $0\le i\le M_s-1$,

$N_c=\max\{0,\lfloor[N_{RB}^{DL}\cdot(N_{sc}^{RB}\cdot c-4)]/36\rfloor\}$ where c is a value out of {0, 1, 2, 3} such that $N_c\le N_{CCE}<N_{c+1}$, N_{RB}^{DL} is a downlink bandwidth configuration, expressed in units of N_{sc}^{RB}, N_{sc}^{RB} is a resource block size in the frequency domain, expressed as a number of subcarriers, and $N_{PUCCH}^{(1)}$ is a starting PUCCH channel index for a PUCCH region in an uplink subframe and is configured by high layers for each UE; and

$n_{PUCCH,i}^{(1)}$ where the value for $n_{PUCCH,i}^{(1)}$ is determined according to higher layer signaling and a table for PUCCH resource value for downlink SPS when the secondary HARQ bundling window size Ms>1 and the primary HARQ bundling window size Mp=0 for the PDSCH transmission where there is not a corresponding PDCCH in subframe $n-k_i$ on the SCell.

15. The device of claim **14**, wherein the HARQ-ACK response is represented as HARQ-ACK(i) and includes a combination of ACK, negative ACK (NACK), or discontinuous transmission (DTX) responses from sub-frame $n-k_i$ on the SCell, where $k_i\in K$ and K is a set of M elements $\{k_0, k_1, \ldots k_{M-1}\}$ and $0\le i\le M_s-1$.

16. The device of claim **14**, wherein higher layer signaling includes radio resource control (RRC) signaling.

17. The device of claim **13**, wherein the processor is further configured to:

determine the HARQ-ACK response for the subframe for the SCell by applying the values of the constellation bits and the PUCCH resource to a HARQ-ACK multiplexing look-up table based on a HARQ bundling window size M=Ms, where Ms is the secondary HARQ bundling window size, wherein the HARQ-ACK multiplexing look-up table is represented by:

a Table 10.1.3-5 in a Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard Release 11 Technical Specification (TS) 36.213 when Ms=2;

a Table 10.1.3-6 in the TS 36.213 when Ms=3; or

a Table 10.1.3-7 in the TS 36.213 when Ms=4,

wherein the Table 10.1.3-5 in the TS 36.213 is:

HARQ-ACK(0), HARQ-ACK(1)	$n_{PUCCH}^{(1)}$	b(0)b(1)
ACK, ACK	$n_{PUCCH,1}^{(1)}$	1, 0
ACK, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 1
NACK/DTX, ACK	$n_{PUCCH,1}^{(1)}$	0, 1
NACK, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 0
DTX, NACK/DTX	No Transmission	

the Table 10.1.3-6 in the TS 36.213 is:

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	$n_{PUCCH}^{(1)}$	b(0)b(1)
ACK, ACK, ACK	$n_{PUCCH,2}^{(1)}$	1, 1
ACK, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	1, 0
ACK, NACK/DTX, ACK	$n_{PUCCH,2}^{(1)}$	1, 0
ACK, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 1
NACK/DTX, ACK, ACK	$n_{PUCCH,2}^{(1)}$	0, 1
NACK/DTX, ACK, NACK/DTX	$n_{PUCCH,1}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK	$n_{PUCCH,2}^{(1)}$	0, 0
NACK, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 0
DTX, NACK/DTX, NACK/DTX	No Transmission	

the Table 10.1.3-7 in the TS 36.213 is:

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	$n_{PUCCH}^{(1)}$	b(0)b(1)
ACK, ACK, ACK, ACK	$n_{PUCCH,1}^{(1)}$	1, 1
ACK, ACK, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	1, 1
ACK, ACK, NACK/DTX, ACK	$n_{PUCCH,0}^{(1)}$	1, 0
ACK, ACK, NACK/DTX, NACK/DTX	$n_{PUCCH,1}^{(1)}$	1, 0
ACK, NACK/DTX, ACK, ACK	$n_{PUCCH,3}^{(1)}$	1, 1
ACK, NACK/DTX, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	1, 0
ACK, NACK/DTX, NACK/DTX, ACK	$n_{PUCCH,0}^{(1)}$	0, 1

-continued

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	$n_{PUCCH}^{(1)}$	b(0)b(1)
ACK, NACK/DTX, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	1, 1
NACK/DTX, ACK, ACK, ACK	$n_{PUCCH,1}^{(1)}$	0, 0
NACK/DTX, ACK, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	0, 1
NACK/DTX, ACK, NACK/DTX, ACK	$n_{PUCCH,3}^{(1)}$	1, 0
NACK/DTX, ACK, NACK/DTX, NACK/DTX	$n_{PUCCH,1}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK, ACK	$n_{PUCCH,3}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK, NACK/DTX	$n_{PUCCH,2}^{(1)}$	0, 0
NACK/DTX, NACK/DTX, NACK/DTX, ACK	$n_{PUCCH,3}^{(1)}$	0, 0
NACK, NACK/DTX, NACK/DTX, NACK/DTX	$n_{PUCCH,0}^{(1)}$	0, 0
DTX, NACK/DTX, NACK/DTX, NACK/DTX	No Transmission.	

18. The device of claim **13**, wherein the node is selected from the group consisting of a base station (BS), a Node B (NB), an evolved Node B (eNB), a baseband unit (BBU), a remote radio head (RRH), a remote radio equipment (RRE), a remote radio unit (RRU), and a central processing module (CPM).

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